ENVIRONMENTAL MONITORING PROGRAM

Plan of Study

Shell Outer Continental Shelf Lease
Chukchi Sea, Alaska

November 2014

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ACRONYMS AND ABBREVIATIONS

ADCP ....acoustic Doppler current profiler
Ag ....silver
Al..........................aluminum
AMAR..................autonomous multichannel acoustic recorder
ANIMIDA ....Arctic Nearshore Impact Monitoring In Development Area
Ba ....barium
BACI ....before-after-control-impact
bbl/day…,………barrels per day
bbl/hr ....barrels per hour
Be ....beryllium
BOP ....blowout preventer
cANIMIDA ....Continuation of Arctic Nearshore Impact Monitoring In Development Area
Cd ....cadmium
CFR ....Code of Federal Regulations
cm ....centimeter
CoC ....chain of custody
COMIDA CAB ....Chukchi Sea Offshore Monitoring In Drilling Area: Chemical and Benthos
Cr..........................chromium
CSESP ....Chukchi Sea Environmental Studies Program
CTD......................conductivity, temperature, depth
Cu ....copper
DMP ....discharge monitoring program
DMR ....discharge monitoring report
EMP ....environmental monitoring program plan of study
EPA ......................U.S. Environmental Protection Agency
Fe..........................iron
ha ....hectare
Hg ....mercury
IC_{50} ....inhibitory concentration that impacts 50% of a sample population
IHA ....Incidental Harassment Authorization
kg/m^2 ....kilograms per square meter
LOQ ....limit of quantitation
m ....meter
m^2 ....square meter
MARPOL……… International Convention for the Prevention of Pollution from Ships
mg/Kg ....milligrams per kilogram
mg/L ....milligrams per liter
MLC ....mudline cellar
mm ....millimeter
MMPA ....Marine Mammal Protection Act

MQO ....Measurement Quality Objective
NOI ....Notice of Intent
NPDES ....National Pollutant Discharge Elimination System
OBS ....optical backscatter sensor
OCS ....outer continental shelf
OOC Model ....Offshore Operators Committee Mud and Produced Water Discharge Model
OSI ....organic sediment index
PAH......................polycyclic aromatic hydrocarbon
Pb ....lead
PERF ....Petroleum Environmental Research Forum
PSO ....protected species observer
PTD ....proposed total depth
QAPP ....Quality Assurance Project Plan
QA ....quality assurance
QAU ....quality assurance unit
QC ....quality control
ROV ....remotely-operated vehicle
Sb ....antimony
SHC ....saturated hydrocarbon
SOP ....standard operating procedure
SPI ....sediment profile imaging
SPP ....suspended particulate phase
TAH ....total aromatic hydrocarbons
Ti ....titanium
TOC......................total organic carbon
TPH ....total petroleum hydrocarbons
TSS ....total suspended solids
VOC ....volatile organic compound
WET ....whole effluent toxicity
Zn ....zinc

EMP/PERMIT NO.: AKG-28-8100 CROSS REFERENCE TABLE

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1. INTRODUCTION

This document presents the environmental monitoring program plan of study (EMP) to be conducted at the discharge monitoring area within the Shell Gulf of Mexico Inc. (Shell) Burger prospect lease blocks in the Outer Continental Shelf (OCS) of the Chukchi Sea, Alaska, during and following exploratory drilling operations (Figure 1). This EMP is designed to cover all wells and drill rigs selected by Shell. The EMP presented in this document follows the effluent limitations, monitoring requirements, and other conditions set forth in the *Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES) for Oil and Gas Exploration Facilities on the Outer Continental Shelf (OCS) in the Chukchi Sea, permit number AKG-28-8100* (hereafter referred to as Permit No.: AKG-28-8100) issued by the U.S. Environmental Protection Agency (EPA) in compliance with the Clean Water Act.

1.1. EMP Plan of Study Goal and Objectives

The goals of the EMP as stated in Permit No. AKG-28-8100 are:

1. Assess the authorized discharges to evaluate potential impacts on water, sediment and biological quality [Permit Section II.A.13.a.1];
2. Implement the EMP through four phases to assess the impacts of oil and gas exploration discharges to the marine environment through time [Permit Section II.A.13.a.2];
3. Protect the marine environment and [Permit Section II.A.13.a.3];
4. Collect data during this permit term for use in future permit development. [Permit Section II.A.13.a.4]

This EMP plan of study outlines the sampling rationale and approach needed to collect high quality environmental data during four assessment Phases, and to validate the USEPA determination that impacts from authorized Arctic offshore exploration drilling discharges will not result in an unreasonable degradation of the marine environment. The sampling design and data analysis are developed to enable comparison to biological and physical data collected in many previous studies as described in Appendix A. The number of sampling stations along with the timing of sampling during periods of maximum discharge should enable the collection of an appropriate data set to be used to assess impacts and provide valuable information for future permit development. However, strict adherence to the number of samples and sampling stations should not be considered an absolute minimum for success in meeting the EMP goals. The amount of data needed will be, to a large extent, determined by the natural biological and physical variability in the study area as well as the extent to which discharges might create a detectible change in baseline conditions. The amount of data collected could be, as well, affected by such factors as weather, sea state, site operations, etc.

The objectives of the EMP, consistent with Permit No.: AKG-28-8100, are:

1. Complete an initial site assessment, including a physical sea bottom survey, to ensure the exploratory facility is not located or anchored in a sensitive biological area or habitat [Permit Section II.A.13.b.1];
2. Evaluate water quality characteristics of the receiving water and potential effects of the specified discharges [Permit Section II.A.13.b.2];
3. Evaluate sediment characteristics of the seafloor and potential effects of the discharges on the sediment characteristics [Permit Section II.A.13.b.3];
4. Evaluate potential effects to the benthic community structure due to deposition of Discharge 001 (water-based drilling fluids and drill-cuttings) and Discharge 013 (muds, cuttings and cement at the seafloor), which includes both spatial and temporal changes in community diversity and abundance [Permit Section II.A.13.b.4]; and
5. Evaluate the suspended particulate and dissolved constituent plume(s) in the vicinity of the discharges [Permit Section II.A.13.b.5].

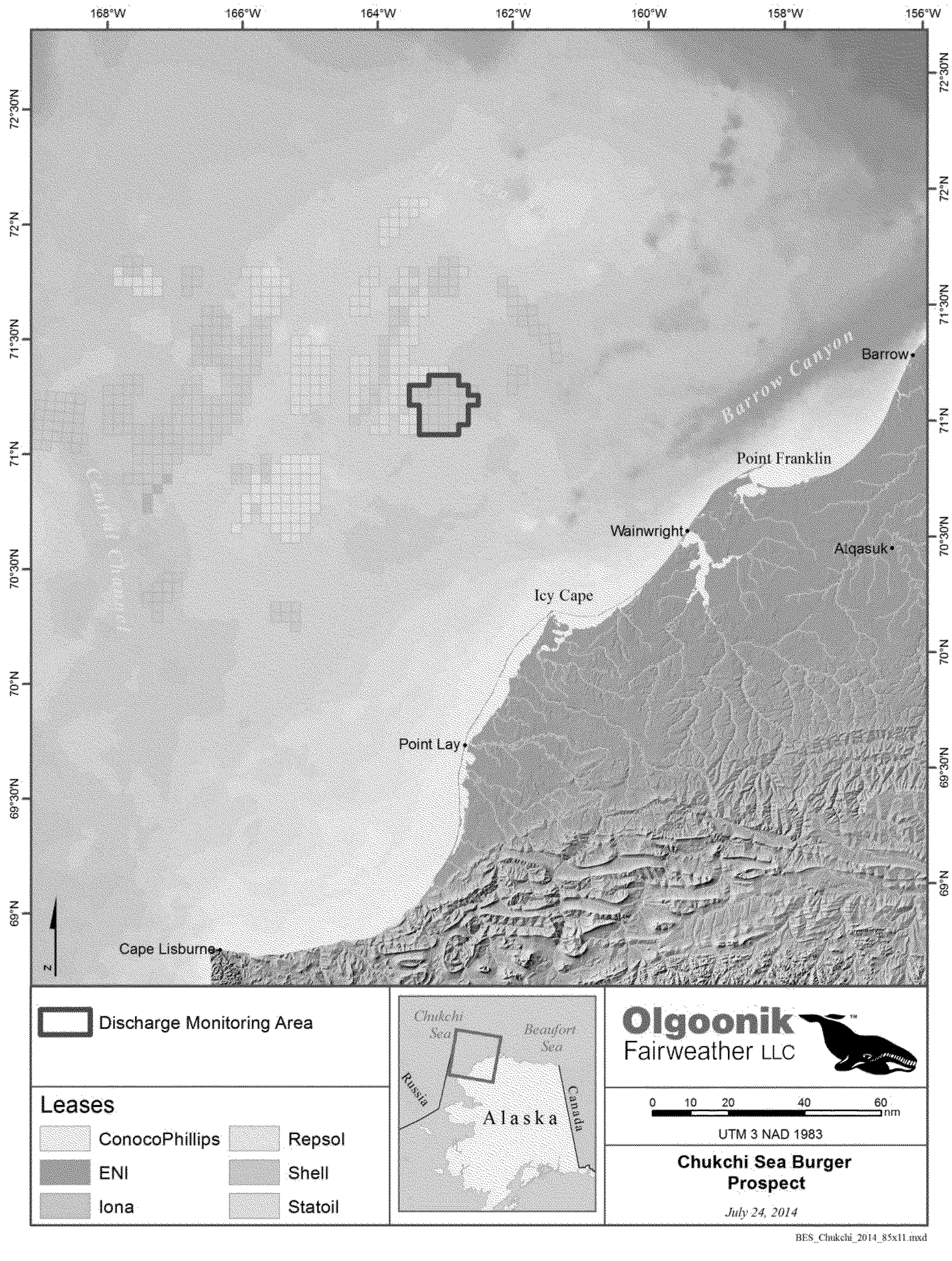

Figure 1: Chukchi Sea Burger prospect.

1.2. Authorized Discharges

Thirteen waste streams are authorized under Permit No.: AKG-28-8100 as shown below in Table 1.

Table 1: Summary of authorized discharges by number and description.[1]

Discharge Number	Description
001	Water-based Drilling Fluids and Drill-Cuttings
002	Deck Drainage
003	Sanitary Wastes
004	Domestic Wastes
005	Desalination Unit Wastes
006	Blowout Preventer Fluid
007	Boiler Blowdown
008	Fire Control System Test Water
009	Non-contact Cooling Water
010	Uncontaminated Ballast Water
011	Bilge Water
012	Excess Cement Slurry
013	Muds, Cuttings and Cement at the Seafloor

[1]In the event that a particular discharge does not occur, the requirements associated solely with that discharge will not be conducted.

The permitted discharges result from normal drilling activitie s, such as sanitary and domestic wastes and desalination unit wastewaters (e.g., released from g eneration of drinking water), and discharges specific to drilling activities, specifically dr illing fluids/muds, drill-cuttings, and cement.

2. BACKGROUND

Shell plans to drill exploratory wells on the Chukchi Sea OCS in accordance with exploration plans submitted to and permits received from the U.S. Department of Interior.

2.1. Chukchi Sea Site Description

The OCS area of the Chukchi Sea is north of the Bering Sea and west of the Beaufort Sea and contains approximately 11,000 square kilometers of active leases for oil and gas exploration and development. The portion of the Chukchi Sea where exploration drilling is planned is north of 70°N latitude (Figure 1). Both the Chukchi and Beaufort Seas were explored in the late 1980s and early 1990s for potential oil and gas development and have been further characterized following lease sales in 2005, 2007 and 2008. The location of the Chukchi Sea north of the Arctic Circle requires that field work and data collection be carefully planned, due to its remoteness, cold temperatures, and presence of sea ice for most of the year.

OCS Lease Sale 193 was held in February 2008 and Shell was subsequently awarded 275 lease blocks through a competitive bidding process. The locations of the lease blocks in the Burger Prospect and the drill sites addressed in this EMP are indicated in Figure 2. Water depth in this part of the OCS is shallow, ranging from 40 to 50 meters (m) deep. Predominant wind direction is from the northeast. Tides are negligible. Shell measured current velocity at the Burger prospect continuously through the use of a seabed mounted acoustic Doppler current profiler (ADCP) from October 2008 through mid-August 2012. Data collected and analyzed over this time period indicates that directionally, currents in the earlier part of the open water season tend to flow towards the north to east. Later in the season, the current direction becomes more variable, with currents moving in the west to southwest direction. This effect can influence the entire water column and not just the surface currents. The exploration drilling and monitoring activities are anticipated to occur during the open-water season.

2.2. Chukchi Sea Drilling Operations

Currently, Shell plans to drill up to six wells in the Burger pros pect using two drill vessels. The drill vessels will be attended by a group of support vessels, including support for ice management, anchor handling, refueling, resupply and oil spill response. Table 2 lists the coordinates of the possible drill site locations.

Table 2: Possible drill site locations in the Burger prospect.

Prospect	Well	Area	Block	Lease Number	Coordinates (m) X	Coordinates (m) Y	Latitude	Longitude
Burger	A	Posey	6764	OCS-Y-2280	563945.26	7912759.34	N71°18'30.92"	W163°12'43.17"
Burger	F	Posey	6714	OCS-Y-2267	564063.30	7915956.94	N71°20'13.96"	W163°12'21.75"
Burger	J	Posey	6912	OCS-Y-2321	555036.01	7897424.42	N71°10'24.03"	W163°28'18.52"
Burger	R	Posey	6812	OCS-Y-2294	553365.47	7907998.91	N71°16'06.57"	W163°30'39.44"
Burger	S	Posey	6762	OCS-Y-2278	554390.64	7914198.48	N71°19'25.79"	W163°28'40.84"
Burger	V	Posey	6915	OCS-Y-2324	569401.40	7898124.84	N71°10'33.39"	W163°04'21.23"

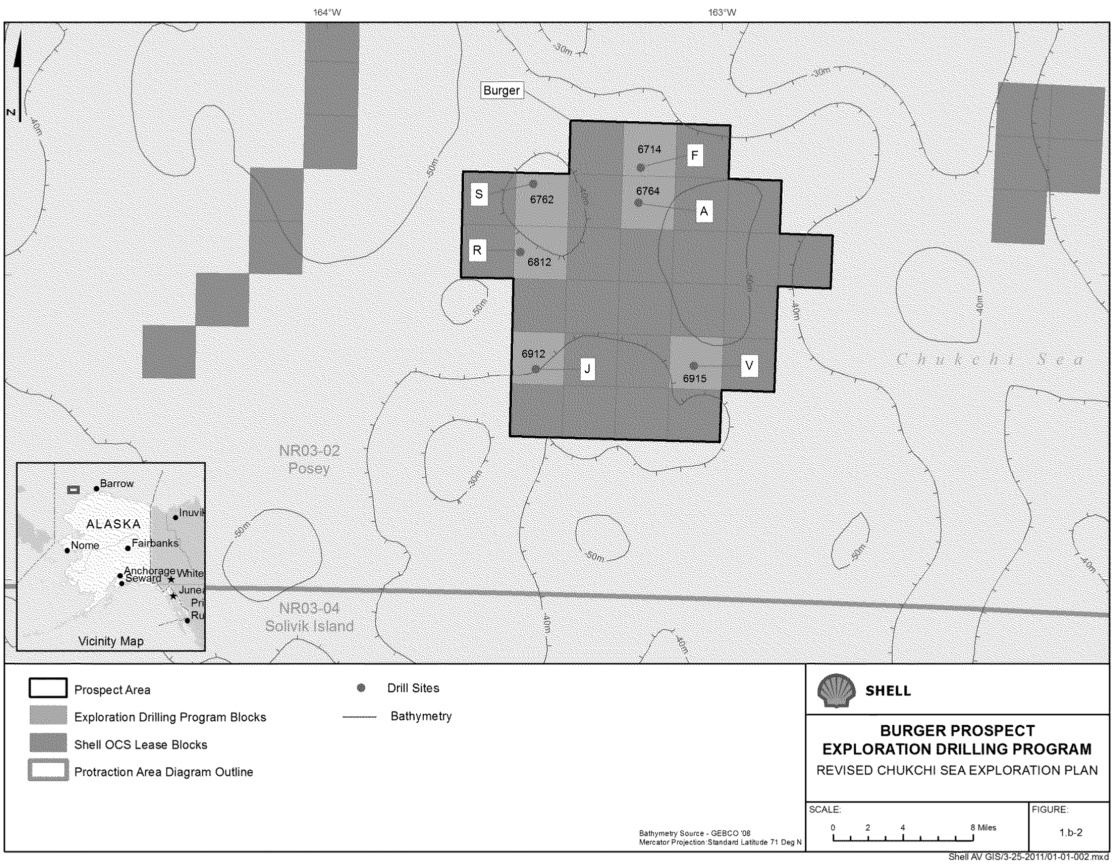

Figure 2: Burger prospect exploration drilling program.

2.2.1. Drilling Operations

Well drilling operations begin with the creation of a tophole. A tophole consists of the hole section(s) drilled prior to installing a blowout preventer (BOP) stack. The design also includes a slim pilot hole to evaluate the site for shallow hazards and a self-supporting mudline cellar (MLC). The MLC is drilled in such a manner as to create a subsurface space that is approximately 20 feet in diameter and 40 feet deep. This space is used to house the wellhead, casing, and BOP stack to protect them from possible damage during ice gouge events. The tophole/MLC may be drilled by either a drill rig or MLC remotely operated vehicle (ROV) system. The precise configuration of hole sizes and depths will depend on how the well is designed.

During the drilling of the tophole, muds and cuttings (D013) will be discharged and deposited at the seafloor. During cementing of casing strings, muds and cement (D013) from the tophole portion will be deposited on the seafloor and/or on the bottom of the MLC.

After the tophole is completed, drilling is advanced through the BOP stack and marine riser (a pipe that provides a temporary extension of the well to the drill rig). Water-based drilling fluids and drill-cuttings are transported up the riser to the drilling unit. There the drill-cuttings are separated from the water-based drilling fluids by solids control equipment. The separated solids (drill-cuttings) are discharged into the sea and the reclaimed water-based drilling fluid is used to continue the drilling process.

After prolonged drilling, the water-based drilling fluid properties degrade through exposure to temperatures and pressures in the well and by dilution with water and clay-sized cuttings particles. At that point, a portion of the water-based drilling fluid may be discharged to allow for water-based drilling fluid reformulation. At the end of the drilling operations, water-based drilling fluids may be discharged in bulk.

2.2.2. Drilling Fluid/Mud Formulation

Shell plans to use water-based drilling fluids. Due to the very limited environmental impact of water-based drilling fluids, which have low toxicity characteristics (Neff 2010, Petroleum Environmental Research Forum [PERF] 2005), they are an authorized discharge (D001, defined as "Water-based drilling fluids" and D013, defined as "Muds") under Permit No.: AKG-28-8100 (EPA 2012a).

The primary purposes of drilling fluids are to cool and lubricate the drill bit, remove cuttings, and maintain pressure and formation stability (Neff 2010). The drilling fluid is formulated to suit the nature of the formation being drilled, plus factors such as depth, temperature and pressure. As the hole is advanced to its proposed total depth (PTD), progressively more complex mud formulations may be used to control the properties of the drilling fluid, which is continually reconditioned and recirculated back down the drill string. Various additives are used to improve the properties of the drilling fluid such as density enhancers, fluid loss reducers, viscosity agents, lubricants, dispersants and shale reactivity inhibitors. Other additives may include biocides, oxygen scavengers and corrosion inhibitors. All additives are pre-tested to ensure their toxicity does not exceed required limits. Specific details on the drilling fluids to be used for the exploratory drilling in the Burger prospect can be found in the drilling fluids plan included in the Notice of Intent (NOI).

The primary ingredients of a typical water-based drilling fluid include brine, fresh water, barite (barium sulfate [$BaSO_4$]), inhibitors and biopolymers. Agents such as barite are added to increase mud weight to counterbalance pressures at depth in the well. Small volumes of mud are periodically discharged in bulk and replaced with seawater to control the flow properties of the fluid. Because barite is used as a weighting agent in drilling fluids, barium (Ba) can typically be found in concentrations that are elevated above background in the immediate vicinity of drilling operations and in the areas where the discharge plume is deposited.

Heavy metals such as copper (Cu), lead (Pb) and zinc (Zn) may be found in trace concentrations in drilling fluids and drill-cuttings; however, these elements do not readily bioaccumulate (Neff 2010). Although the spent water-based drilling fluids could potentially contain various other additives, these materials represent only a small fraction of the overall drilling fluid volume (Neff 2008, Neff 2010). Most water-based drilling fluid additives are not bioavailable, are non-toxic, and/or are used in such small amounts that they are not present at high enough concentrations to contribute significantly to toxicity (Trefry and Smith 2003, Neff 2008). Cadmium (Cd) and mercury (Hg) limitations are specified by Permit No.: AKG-81-2800 and limit the stock barite concentrations to 3.0 and 1.0 mg/kg (ppm), respectively.

The entire water-based drilling fluid formulation goes through extensive toxicity testing and is verified to not exceed EPA's toxicity requirements (EPA 1993, EPA 2000, EPA 2006, EPA 2012a, b) prior to use. The results of these toxicity tests are provided in the drilling fluids plan.

The manner in which the drill rig is operated and the nature of the geological formation may contribute chemical constituents to the water-based drilling fluid as the hole is advanced through the natural stratigraphic sequence. As such, naturally occurring oil, condensate, and/or gaseous hydrocarbons may become entrained in the fluid. Both metals and hydrocarbons generally are bound to clays or humates which limits their bioavailability (Neff 2010).

2.2.3. Discharge Streams

Anticipated drilling discharge streams from the drill rig are listed in the NOI. Water-based drilling fluids, drill-cuttings, and cement discharges are typically discharged intermittently during drilling operations.

During drilling, there may be one or more bulk water-based drilling fluid discharges that occur over varying time periods. These brief water-based drilling fluid discharges and the more frequent, lower-rate discharges of drill-cuttings will be released below the sea surface. Depending on prevailing oceanographic conditions, these discharges may or may not be visible from the rig or any vessels in the vicinity. The water-based drilling fluid and drill-cuttings plumes will dilute to background levels mainly through the settling of the solids onto the sea floor (Neff 2010). Modeling efforts conducted specific to the Shell exploratory drilling program also demonstrate rapid dilution of discharges to background levels.

The largest drilling discharge by volume will be drill-cuttings. When discharged to the ocean, water-based drilling fluids and drill-cuttings, which are slurries of particles of different sizes and densities in water containing dissolved inorganic salts and low levels of organic chemicals, form a plume that dilutes rapidly as it drifts away from the discharge point with the prevailing water currents (Figure 3).

The water-based drilling fluids and drill-cuttings discharge undergoes dispersion, dilution, dissolution, flocculation and settling in the water column. Most dissolved components, such as sodium chloride, exiting the system continue to dilute rapidly by turbulent mixing (eddy diffusion) of the receiving waters (Neff 2010). The water-based drilling fluids and drill-cuttings plumes are expected to partition into two phases: (1) a dense, rapidly-settling particulate solids phase (~90% of total mass of mud and cuttings solids), and (2) an upper-water-column, slowly-settling phase containing fine-grained (clay-size) particles and dissolved ingredients of the discharge (~10% of total mass; Neff 2010). Because of the shallow water depth at the drill sites and the distance between the bottom of the disposal system and the seafloor, the two plumes will be co-mingled, with the larger, denser particles settling to the sea floor nearer to the rig than the fine particles. Fine-grained particles (clays) in the upper plume will remain suspended at or below the discharge depth (the plume water will have a salinity and density similar to or higher than that of the ambient seawater) or settle slowly and be carried away in the direction of the mid-depth currents.

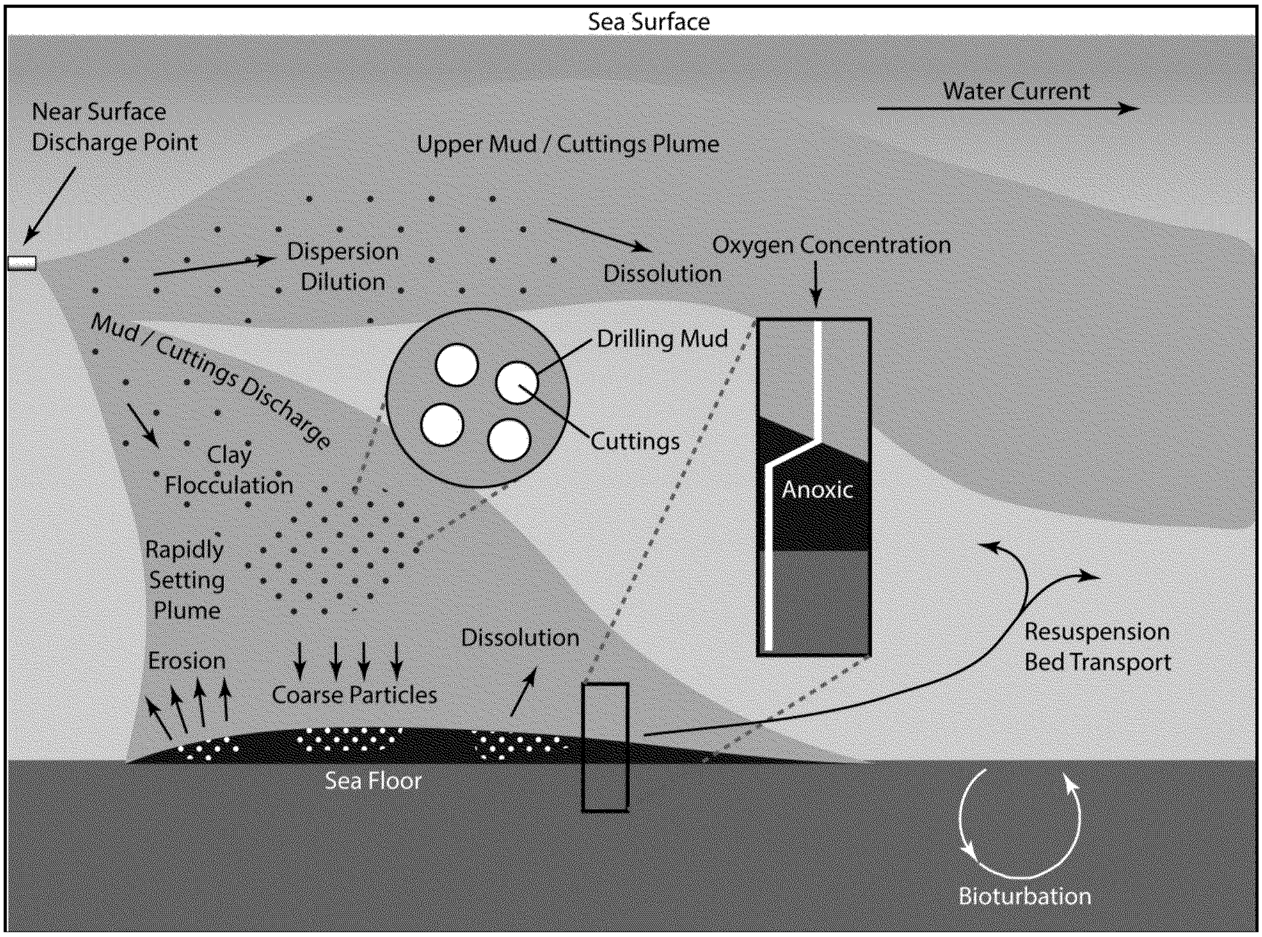

Figure 3: Dispersion and fates of water-based drilling fluids and drill-cuttings following discharge to the ocean (Modified from Neff 2010). The water-based drilling fluid often forms two plumes, an upper plume containing fine-grained unflocculated solids and dissolved components of the fluid, and a lower, rapidly-settling plume containing dense, larger-grained particles, including cuttings, and flocculated clay/barite particles. The call out circle in the figure demonstrates that drilling fluids (termed "muds" in the figure) coat the cuttings particles. The rectangular call out in the figure depicts the reduction in oxygen concentration if sediments become anoxic as a result of discharge deposition.

The denser particles in the settling plume will sink quickly as they drift away from the discharge site, with the rate of sinking depending on particle size and density relative to seawater density at different depths in the water-column. The density of seawater increases with increasing depth (pressure) and salinity and with decreasing temperature. The continuous phase of both the gel water-based drilling fluid that will be used to drill the upper (wider) hole and the inhibitive polymer water-based drilling fluid that will be used to drill the deeper (narrower) sections of the well is a sodium chloride brine that will be denser than seawater; thus, the water-based drilling fluid plume will sink. Water-based drilling fluid and drill-cuttings particles may accumulate at a water depth where the density of the water and particles is the same.

2.2.4. Modeling Results

2.2.4.1. Dispersion and Deposition Modeling for Discharge 001 and Discharge 013

Understanding the extent to which drilling fluids and drill-cuttings, when discharged, will affect the water column and sea floor has been extensively studied by the use of predictive dispersion models (Neff 2010). The Offshore Operators Committee (OOC), a consortium of companies operating in the waters of the Gulf of Mexico, sponsored the development of a model to predict the fate of drilling fluids discharged into the offshore environment (Brandsma and Smith 1999, Alam and Brandsma 2013). The OOC model predicts the fate of drilling fluids, drill-cuttings, or produced water discharged from a single discharge point. Particulates may be solids or droplets. The model predicts the concentrations of particles and liquids in the water column and the deposition of solid particles onto the sea floor. There are no restrictions on the nature of the receiving environment simulated by the OOC model. Thus it is appropriate for use in the Chukchi Sea. The model provides for the ambient bathymetry to be variable or a constant depth. Currents and hydrography may be input to simulate both spatial and temporal changes. Sea state may also be modeled to change temporally.

A series of modeling exercises was conducted in order to understand the range of discharge conditions expected for the 2015 drilling season. These conditions include the discharge characteristics of the drillship Noble Discoverer and the drill rig Polar Pioneer that will be used for drilling in the Burger Prospect (e.g. flow rate, discharge pipe diameter, location of discharge points below water surface), the well design, and the expected range of conditions for water temperature, wind speeds, currents, and salinity. Generally, the majority of water-based drilling fluids and drill-cuttings are expected to settle within 500 meters of the discharge location, and total suspended solids (TSS) will create a gradient of decreasing concentration as the plume of material is carried away from the discharge point by the prevailing currents. Concentrations are modeled to be highest at the source, decreasing to background levels at approximately 1000 meters from the discharge location.

Table 3 (sediment thickness) and Table 4 (TSS) below summarize the site-specific modeling analyses for the deposition of solids greater than 1 cm at the sea floor, and the distance from the discharge point where concentrations of TSS are predicted to fall below 15 mg/l for the drilling intervals planned for sampling in Phase II of this EMP. The summary data is shown for the mean current (7 cm/s) and maximum current (25 cm/s) model conditions. Discharge of total cuttings for model purposes includes a 50 % washout factor. That is, cutting volume is estimated to be 50 percent greater than what is expected from the design of the well to account for localized bore-hole erosion during the drilling process.

This information was then used to help guide the technical approach and sample design for both plume monitoring and sea floor sampling as described in Sections 3.2.4.2 and 3.3.1 of this EMP. The modeling reports for each scenario (Fluid Dynamix, 2014a-h) are also provided as Appendix B to the EMP.

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Table 3: Estimates of depositional area of solids in hectares from OOC modeling of discharges from the Burger Prospect by drillship Noble Discoverer and drill rig Polar Pioneer

The OOC Model Predictions of depositional area greater than 1 cm thickness at the Mean and the Maximum Currents Speed						
	Total Durations of Discharge	Discharge of the Total Cuttings including 50% Washout	Total Area (in hectares) Drill Rig Discoverer		Total Area (in hectares) Drill Rig Polar Pioneer	
Well ID	Hours	bbls	At Mean Currents	At Maximum Currents	At Mean Currents	At Maximum Currents
Burger F	195.1	6,049	0.52	1.07	0.51	1.05
Burger J	195.1	6,930	0.56	1.06	0.51	0.99
Burger S	195.1	6,080	0.52	1.07	0.51	1.05
Burger V	195.1	6,243	0.57	1.13	0.52	1.07

Table 4: Estimates of total suspended solid (TSS) in mg/L from OOC modeling of discharges from the Burger Prospect by drillship Noble Discoverer and drill rig Polar Pioneer.

The OOC Model Predictions of Distance in meters from the Source at which TSS is 15 mg								
	Drillship Noble Discoverer During Maximum discharge from Interval 4		Drill Rig Polar Pioneer During Maximum discharge from Interval 4		Drillship Noble Discoverer during Maximum discharge from the surface pits		Drill Rig Polar Pioneer during Maximum discharge from the surface pits	
Well ID	At Mean Currents	At Maximum Currents	At Mean Currents	At Maximum Currents	At Mean Currents	At Maximum Currents	At Mean Currents	At Maximum Currents
Burger F	140	265	140	245	665	1,630	670	1,570
Burger J	103	220	101	210	670	1,630	670	1,575
Burger S	145	265	140	215	670	1,630	670	1,575
Burger V	150	285	150	225	670	1,630	670	1,565

2.2.4.2. Temperature Associated with Non-contact Cooling Water (Discharge 009)

Numeric modeling for the thermal dispersion was conducted using the *US EPA Dilution Models for Effluent Discharges – Visual Plumes (4th Edition)* to characterize the impact on ambient sea water temperature associated with the non-contact cooling water discharges (Permit No.: AKG-28-8100, Discharge 009). The modeling was performed for both a mean current (7 cm/sec) and a maximum current condition (25 cm/sec). The drillship Noble Discoverer will discharge approximately 107,300 barrels per day (bbl/day) of the non-contact cooling water from six (6) different outlets located on this drillship. The drill rig Polar Pioneer will discharge approximately 21,385 bbl/day of the non-contact cooling water from a single outlet located on this drill rig.

The thermal dispersion simulations were performed using the effluent and ambient data for the planned drilling period. The planned drilling period is within the open water season of July through October. The direction of the discharge was assumed to be aligned with the prevailing current direction for the modeling purpose since the current bends the plume in the direction of flow (Frick 2003). The modeling assessment evaluated the volume of sea water that would be elevated 0.05 °C above the ambient sea water temperature. Discharged non-contact cooling water temperatures that were modeled ranged from approximately 4 to 16 °C. The duration of the discharges was input to be 24 hours per day during the drilling operational period. Sea water temperature varies in the model from 4 °C at the surface to - 0.5 °C at the sea floor.

For the drillship Noble Discoverer, the *Visual Plumes* model predicted that the maximum plume depth would be 5 m with a maximum plume width at 54 m, and the maximum distance from the drill rig to be 218 m. The length of time for the plume to cool within 0.05 °C of the ambient temperature after the cessation of the discharge was predicted to be 56 minutes; and the total area affected by the discharge was estimated at 1.34 hectares (ha). For the drill rig Polar Pioneer, the *Visual Plumes* model predicted that the maximum plume depth would be 2 m with a maximum plume width at 68 m, and the maximum distance from the drill rig to be 355 m. The length of time for the plume to cool within 0.05 °C of the ambient temperature after the cessation of the discharge was predicted to be 78 minutes; and the total area affected by the discharge was estimated at 1.4 hectares (ha). These estimates indicate low impacts on the ambient water quality from the temperature associated with the Discharge 009 (non-contact cooling water) from the six (6) different outlets located on the drillship Noble Discoverer or the single outlet on the drill rig Polar Pioneer.

Similar to the modeling output for drill fluids/cuttings, this information was used to help guide the technical approach and sample design for both plume monitoring as described in Sections 3.2.4.2 of this EMP. The modeling reports for each scenario (Fluid Dynamix, 2014i,j) are provided in Appendix C to the EMP.

3. OVERALL TECHNICAL APPROACH AND SCOPE

The EMP technical approach and scope described below has been developed to achieve the objectives required by the four assessment Phases (I, II, III, and IV) as described in Permit No.: AKG-28-8100 and shown in Table 5. The technical approach and scope presented apply to any wells drilled in the Burger prospect utilizing any drill rig.

Table 5: Summary of four EMP Phases required by Permit No.: AKG-28-8100. [Permit Section II.A.13.c]

Phase	Component
I	Baseline site characterization
II	During active drilling
III	Post-drilling
IV	No later than 15-months after drilling operations cease at a drilling site

The Phase I assessment requires a physical site characterization which includes:

1. An initial site physical sea bottom survey to ensure the drilling site is not located in or near a sensitive biological area or habitat. [Permit Section II.A.13.f.1]
2. Physical characteristics: surface wind speed and direction, current speed and direction throughout the water column, water temperature, salinity, depth, and turbidity. [Permit Section II.A.13.f.2]
3. Receiving water chemistry and characteristics to include dissolved metals, pH, turbidity, total suspended solids, total aqueous hydrocarbons, and total aromatic hydrocarbons. [Permit Section II.A.13.f.3]
4. Benthic community structure; infaunal and epifaunal invertebrates, bivalves, and crustaceans. [Permit Section II.A.13.f.4]

The Phase II assessment will be conducted during drilling activities and includes:

1. Effluent toxicity characterization; rapid automated toxicity testing system as an initial screening method; whole effluent toxicity if initial screening method shows potential toxicity: or once per well if the discharges exceed 10,000 gallons during any 24-hour period and if chemicals are added to the system. [Permit Section II.A.13.g.1]
2. Water-based drilling fluids/drill-cuttings (Discharge 001) plume monitoring and observations for potential marine mammal deflection during periods of discharge [Permit Section II.A.13.j.4] and Non-contact cooling-water (Discharge 009) plume observations for potential marine-mammal deflection during periods of discharge [Permit Section II.A.13.g.2]
3. Water-based drilling fluids /drill-cuttings metals analysis. [Permit Section II.A.13.j.1]

4. Plume monitoring and observations: sample and assess metals, orga nics, turbidity, and total suspended solids. [Permit Section II.A.13.j.4]

Phase III and IV assessments are conducted following the completion of drilling activities at a drilling site. Phase III components will be conducted as soon as prac ticable immediately after drilling [Permit Section II.A.13.h.2] and include:

1. Physical sea bottom survey; areal extent and depth/thickness of sol ids deposition caused by Discharges 001 and 013. [Permit Section II.A.13.h.1]
2. Sediment characteristics and discharge effects: chemistry, grain size, pollutant concentrations. [Permit Section II.A.13.j.2]
3. Benthic community bioaccumulation monitoring. [Permit Section II.A.13.j.3]

Phase IV assessments will be conducted no later than 15 months after drilling operations cease at a drilling site [Permit Section II.A.13.c] and include all components from the Phase III assessment with the addition of evaluation of the benthic community st ructure. [Permit Section II.A.13.i.2]

3.1. Phase I Assessment; Use of Data from Previous Studies

Permit No.: AKG-28-8100 requires a baseline site characterizat ion to be conducted as part of the Phase I assessment; however, Permit No.: AKG-28-8100 allows for data collected under other agency requirements or by industry lead efforts within the most r ecent 5-year period, at or in the vicinity of the drill site location, to be submitted for consideration of meeting this requirement. This section, in conjunction with Appendix A, demonstrates that sufficient data exist throughout the northeast Chukchi Sea to serve as a replacement for the baseli ne characterization assessment required for Phase I sampling at drilling locations within the Burger study area.

A substantial amount of baseline science and site characterization data e xists for the Chukchi Sea OCS as a result of extensive, multidisciplinary research progr ams (both industry and government) that have been conducted. Data collected over the past five to six years exist for the Chukchi Sea from two large, comprehensive multi-year baseline study programs.

The *Chukchi Sea Offshore Monitoring in Drilling Area: Chemical and Benthos (COMIDA CAB)*, a Bureau of Ocean Energy Management funded study, collected chem ical and benthic-ecology data for two years in 2009 and 2010. An extension of *COMIDA CAB—Hanna Shoal Ecosystem Study*, a 2-year program begun in 2012, collected chemical and benthic-ecology data in 2012 and 2013. The COMIDA CAB sampling stations in the northeastern Chukchi Se a are shown in Figure 4.

The Chukchi Sea Environmental Studies Program (CSESP), http://www.chukchiscience.com, a joint industry-funded study begun in 2008, has collected a diverse and mult i-disciplinary dataset since its inception. CSESP studies pertinent to Phase I include e nvironmental chemistry and benthic ecology, as well as physical oceanography, and marine ma mmal surveys. CSESP data were collected at three 30x30 nautical mile blocks that assured co verage of the Shell, ConocoPhillips, and Statoil lease blocks. Only the Burger study ar ea stations (along with some contemporaneous stations in the immediate vicinity of the Burger study area) are included in the proposed Phase I dataset (see Figure 4) and presented in Appendix A to this document.

In addition, a discharge monitoring program (DMP) was conducted by Shell, in 2012, in which Phase I assessment-equivalent data were collected at 18 stations around the Burger A drill site. The DMP stations represent spatially-intensive sampling points and are shown in Figure 4 (insets). These programs (i.e., COMIDA CAB, CSESP, and DMP) are a unique combination of government-funded and industry-funded studies that provide a comprehensive data set specific to the northeastern Chukchi Sea region, the Burger prospect area, as well as the specific drill site at Burger A.

Information generated from these programs, representing different geographical parts of the Chukchi Sea, was compiled and synthesized and is presented in Appendix A. Data analyses were conducted to determine variability within and among data sets from the same region and to establish that historical data from this large geographical area is predictive of current baseline data at site-specific locations. The Appendix A summary clearly demonstrates that existing information and data are sufficient to characterize baseline conditions as required in Permit No.: AKG-28-8100. The data comparison also indicates that the spatially intensive sampling conducted at the Burger A drill site in 2012 (Shell DMP) are similar to the data from the larger Burger prospect (i.e., data from CSESP and COMIDA-CAB). This indicates homogeneity in the Burger region and demonstrates that additional Phase I drill site specific information does not need to be collected. Moreover, there have been no sensitive biological areas or habitats identified in the Burger prospect. Appendix A also provides additional baseline data, sediment characteristics and benthic community bioaccumulation monitoring, to compare to future data collected as part of the Phase III and IV assessment of the EMP.

All Phase I components are addressed in Appendix A with the exception of a subset of the full suite of dissolved metals (Permit Section II.A.13.f.3.Table A) and hydrocarbons for the receiving water characterization. Some of the metals have not been analyzed prior to the release of Permit No.: AKG-28-8100 because metals such as titanium are not generally included in these types of analyses due to their limited environmental significance. Therefore, to comply with the full extent of the receiving water requirements in Permit No.: AKG-28-8100, remaining Phase I data (i.e., water samples) will be collected immediately prior to or during the Phase II sampling activities. Samples will be collected at reference stations located outside the expected/modeled deposition from the drilling operations.

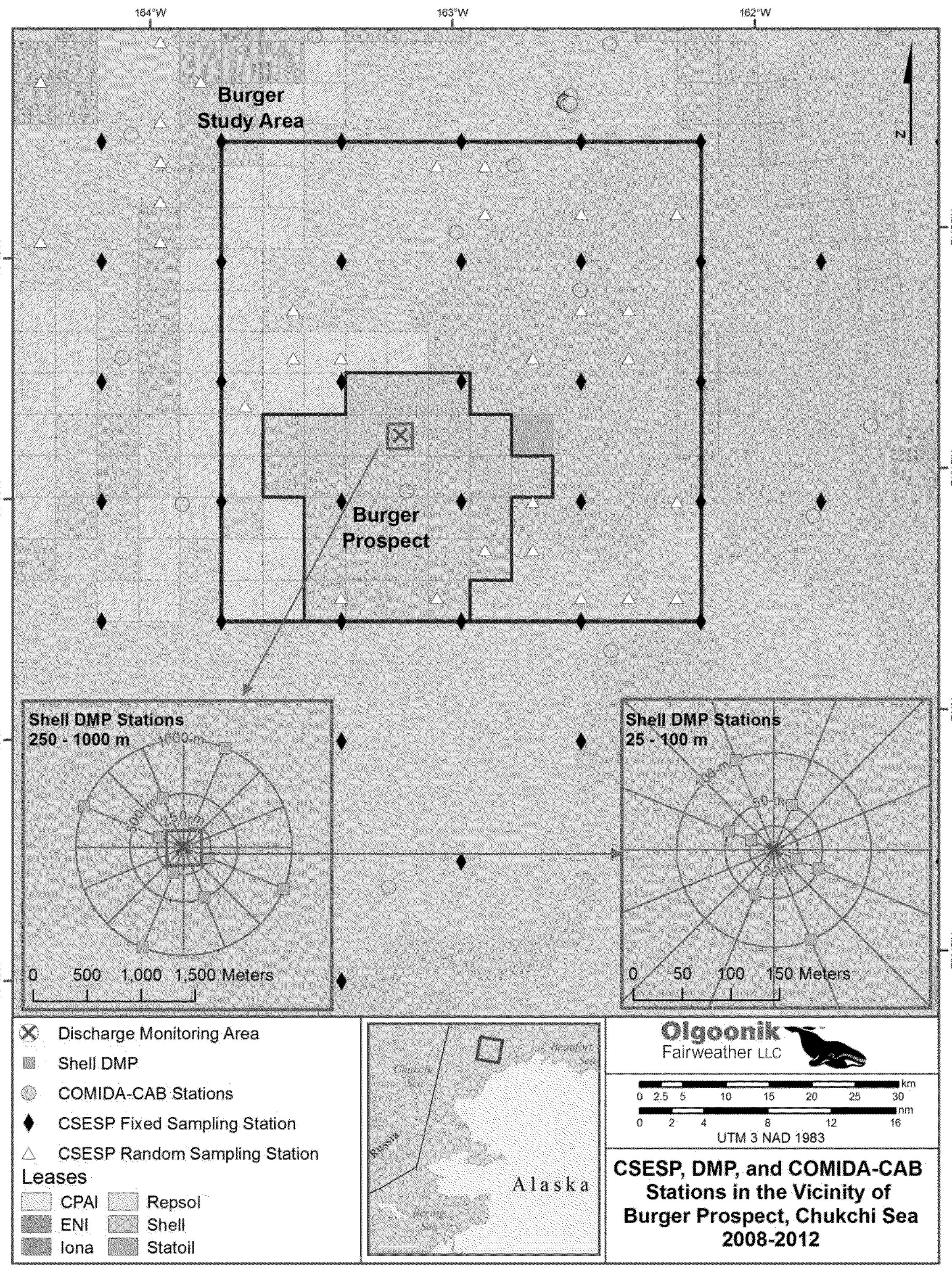

Figure 4: CSESP, DMP and COMIDA CAB stations in the vicinity of Burger prospect, Chukchi Sea, 2008-2012.

3.2. Phase II Assessment

The objective of the Phase II assessment is to characterize, to the extent possible, the physical and chemical concentrations throughout the discharge-affected water column and discharge plume. The Phase II assessment will be conducted during drilling activities and includes:

1. Effluent toxicity characterization [Permit Section II.A.13.g.1];
2. Water-based drilling fluids/drill-cuttings (Discharge 001) plume monitoring and observations for potential marine mammal deflection during periods of discharge [Permit Section II.A.13.j.4] and Non-contact cooling-water (Discharge 009) plume observations for potential marine-mammal deflection during periods of discharge [Permit Section II.A.13.g.2];
3. Water-based drilling fluids/drill-cuttings metals and hydrocarbon analysis [Permit Section II.A.13.j.1]; and
4. Plume monitoring and observations [Permit Section II.A.13.j.4].

Of these four required components, effluent toxicity characterization and plume monitoring and observations (e.g., sensor and visual) require the most intensive sampling and analysis. The metals and hydrocarbon analysis of the water-based drilling fluids/drill-cuttings will provide information on chemicals that might be associated with the discharge which will help inform the analysis of samples collected during the plume monitoring component. The results from each of these four required components, taken together, will be used to evaluate any potential water-column impacts from the exploratory drilling activities. The following sections describe the scientific approach for each component.

3.2.1. Effluent Toxicity Characterization

Development of the initial toxicity screening method is critical to effluent toxicity characterization because this will dictate whether whole effluent toxicity (WET) testing is triggered for certain discharges. Thirteen different discharge streams are defined in Permit No.: AKG-28-8100, six of which require toxicity characterization as part of permit compliance. The six discharges are deck drainage (002), desalination (D005), boiler blow-down (D007), fire control test water (D008), non-contact cooling water (D009) and bilge (D011). If there are multiple discharge points for a single discharge stream, a sample will be collected for each.

Toxicity characterization will consist of an initial toxicity screening process using 100 percent effluent at four different time periods in accordance with Permit No.: AKG-28-8100 section II.A.13.g.1.i. If effluent samples fail the initial toxicity screen, as defined by the toxicity testing threshold limits established for this program and described in the project-specific quality assurance project plan (QAPP), then WET will be conducted using three different species of organisms, including the topsmelt, *Atherinops affinis* (or *M. beryllina,* depending on availability), the mysid shrimp, *Americamysis bahia*, and the purple sea urchin, *Strongylocentrotus purpuratus*. The methods for WET testing are provided in established EPA procedures outlined in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and*

Receiving Waters to Marine Organisms (EPA-821-R-02-014 Fourth Ed.) and the *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to West Coast Marine and Estuarine Organisms* (EPA/600/R-95-136).

Upon receipt of the toxicity samples at the laboratory, water quality characteristics will be measured, depending on the particular requirements as laid out in the standard operating procedures (SOPs). For example, temperature, salinity, pH, and dissolved oxygen will be measured. These data can then be used to assess whether physical/chemical conditions were similar between the initial toxicity screening test and (in the event that a positive initial toxicity screening result is obtained) the WET test. A split of the effluent samples will be collected for chemical analysis at the time of sampling. This sample will be submitted to the selected analytical laboratory for analysis and is not a part of the biological testing program.

Water quality conditions for initial toxicity screening and WET testing samples (including temperature, salinity, pH and dissolved oxygen) of each discharge type will be measured to confirm optimal testing conditions are created prior to the addition of test organisms. The process for adjusting effluent solutions to testing conditions is described in the technical laboratory methods section of this document. This process is required in the EPA-approved methods in order to adjust sample conditions to match the optimal conditions for each test organism. A brief description of each discharge type is provided below with considerations for the required toxicity testing. If any discharge systems draw their water source from the natural seawater, it is possible that organisms may be present in those samples. If natural seawater is part of the discharge stream, those samples will be inspected and, if necessary, screened prior to testing.

<u>Discharge 002: Deck Drainage</u> – Deck drainage is the wastewater associated with washing platforms, decks, and equipment, and runoff from curbs, gutters, pans and wash areas from the deck of the drillship or drilling rig. Permit No.: AKG-28-8100 requires deck drainage systems to separate drains associated with oil and grease wastewater from wastewater not in contact with surfaces containing any oil or grease. The wastewater associated with oil and grease drains is processed through an oil-water separator prior to discharge into the Chukchi Sea. The effluent discharged through the oil-water separator will be tested four times during the drilling of the well using the initial toxicity testing screening method described in the QAPP. The salinity of the discharge will be measured and, if necessary, adjusted with brine solutions or artificial sea salts to testing conditions suitable for marine organisms.

<u>Discharge 005: Desalination</u> – Effluent discharges associated with the creation of fresh water from seawater are likely to be high concentration brines similar to seawater in chemical composition but with higher concentrations of anions and cations. The potential high saline conditions of this discharge type may require a reduction of salinity to conditions that are conducive to the tolerant range of test organisms for both initial toxicity testing screen and the WET test.

<u>Discharge 007: Boiler Blowdown</u> – The materials inside the boiler drums, including water and solids, are discharged periodically to minimize solids buildup in the boiler units. It is likely this discharge will be fresh water and contain some amount of solid materials. If necessary, the fresh

water will be adjusted with brine solutions or artificial sea salts to salinity conditions conducive to test organism survival using the guidance provided in the EPA-approved methods for both initial toxicity testing screen and the WET test.

Discharge 008: Fire Control System Test Water – This discharge is created from seawater released during fire training exercises, and testing and maintenance of fire protection equipment. If necessary, the salinity of the fire control system test water will be adjusted to within testing parameters prior to the addition of test organisms.

Discharge 009: Non-contact Cooling Water – Non contact cooling water is uncontaminated, heated seawater created when cold seawater is used to cool machinery on the drill rig. It represents the highest volume of discharge authorized under Permit No.: AKG-28-8100. If necessary, the salinity of the non-contact cooling water will be adjusted to within testing parameters prior to the addition of test organisms.

Discharge 011: Bilge Water – Bilge water drains into the drilling vessel hull and is processed through an oil-water separator. Aquatic organisms may exist in the bilge water discharge. Samples will be visually inspected using a light table to determine if organisms are present in the effluent. If organisms are observed, the effluent will be passed through a Nytex™ screen large enough to capture the organisms prior to the start of any testing.

3.2.1.1. Rapid Screening Test

The rapid screening toxicity testing process is designed to separate effluent discharge samples requiring further toxicity testing from those that do not. Rapidity and sensitivity are two important features of the rapid screening test in order to be a useful tool in achieving water quality goals. There are a number of biological methods that have been developed over the years, with exposure times ranging from less than 1 hour up to 96 hours. The most preferable screening tools for this effluent testing program are those that can be accomplished rapidly (<1hr), such that the sample water, for a WET test if triggered, will still be within the required holding time. This criterion reduces the potential marine screening tools to the Microtox™ test and the echinoderm fertilization test. Table 6 provides general descriptions of potential screening tools, exposure period and method citation.

Table 6: Summary of example rapid screening tools with exposure times of <24hr.

Test Name	Description of Test	Duration (hours)	Method	Reference
Microtox™ - water assay	Bioluminescent bacteria used to detect toxins. Amount of light emitted during exposure provides indication of toxicity compared to control.	0.25/0.50	(marine or freshwater)	Microbics Corporation 1992
Microtox™ sediment assay		0.25/0.50		
Echinoderm Fertilization-water assay	Echinoderm eggs and sperm are combined and the percent of fertilized eggs is an indication of toxicity compared to control.	0.40	EPA, 2002 - 1008.0 (marine)	Lee et al. 1999
Artotox	Brine shrimp exposed to effluent. Toxicity indicated by percent survival compared to control.	24	EBPI procedure (marine)	
QwikSed (dinoflagellate)-sediment assay	Bioluminescent dinoflagellates used to detect toxins. Reduction or inhibition in light used to indicate toxicity.	24	SeaLife Instruments, Florida (marine)	NFESC TDS-2077-Env, Feb 2000
QwikLite (dinoflagellate) - water assay		24		
Toxi-ChromoPad – sediment assay	Bacterium E. coli grown in solid material. If sample is toxic no color will develop. If sample is toxic a blue color develops.	1.5	EBPI procedure (freshwater)	Lee et al. 1999
Thamnocephalus platyurus- water or sediment	Freshwater crustacean exposed to effluent. Toxicity indicated by percent survival compared to control.	0.5 to 1		
Rototox – water or sediment	Rotifers exposed to effluent. Toxicity indicated by percent survival compared to control.	24		ASTM, 1991 E 1440-91

Microtox™ was initially considered as the preferred rapid screen method. Based on further review, as described below, Shell has determined that the echinoderm fertilization water assay is a more suitable and reliable method. A comparison of the Microtox™ test and the echinoderm fertilization test was conducted by Environment Canada (Buday 2001). The relationship between Microtox™ responses and the echinoderm percent fertilization success were not well correlated. The data from this study was graphically compared and is illustrated in Figure 5. Overall conclusions from the review indicate:

- Microtox™ responses in water exposures had no measureable responses for any of the samples tested.
- Microtox™ responses for the solid-phase test had significant reductions in light that occurred over a broad range from an inhibitory concentration that affects 50% of a test population (IC_{50}) of 526.9 to 13,080 mg/L (~25-fold).
    - Solid-phase Microtox™ responses occurred in samples that showed no significant response using the echinoderm test.

- Acceptable echinoderm fertilization occurred over t he entire solid-phase Microtox™ response range (526.9 to 13,080 mg/L) as shown by the blue shaded box in Figure 5.
- Conversely, negative responses from the echinoderm fertilization test showed a range of responses for the Microtox™ test with IC_{50} values occurring at <4,000 mg/L but not for all Microtox™ samples with these same response levels.

- There was no negative response for Microtox™ for th e water exposure (this result was assumed to invalidate the test as an acceptable can didate for this environmental monitoring program).

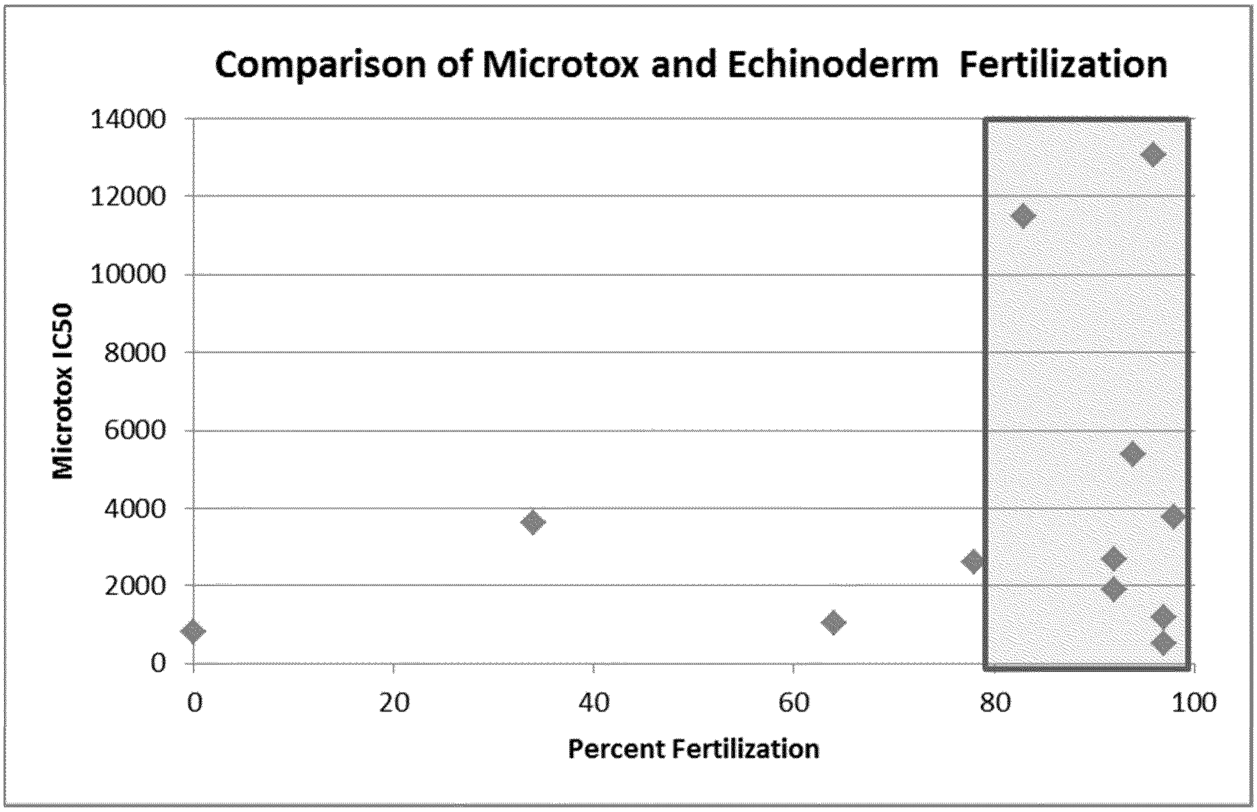

Figure 5: Graphical illustration showing inhibitory concentration that affects 50% of a test population (Microtox™) vs. percent fertilization in echinoderm fertilization test.

In addition to the observations by Buday (2001), a number of studies reported the interference of other environmental parameters, for example element al sulfur and surfactants, on the interpretation of the Microtox™ solid phase results (Jacobs et al. 1992, Pardos et al. 1999, Sherrard et al. 1996). Microtox™ responses in treat ed and untreated effluents were found to show similar results (Dorn et al. 1989). Literature reviews of the apparent toxicity as measured by Microtox™ exhibit wide ranges. For example, Tous sant (1995) found that metal toxicity measured by light output using Microtox™ (IC_{50}) varied by orders of magnitude (e.g., Zn 0.44 to 476 mg/L; Cu 0.076 to 25 mg/L; Cd 11.6 to 416 mg/L) , with a small difference for unionized ammonia ranging from 1.49 to 2 mg/L. Similarly, New Fields (2009) conducted experiments to determine the influence of holding times on the amo unt of light output and found that the longer a sample was held within acceptable holding times and under acceptable temperatures, the higher the incidence of effect on light output; these results appeared to be associated with sulfides and ammonia. Based on the comparison results provided above, the echinoderm fertilization test will be used as the rapid screening tool for this EMP.

Three echinoderm species will be included in the testing guidelines for Permit No.: AKG-28-8100 in order to meet windows of reproductively appropriate time frames. The species would likely include the sand dollar (*Dendraster excentricus*) and the sea urchins (*Strongylocentrotus purpuratus* and *Lytechinus anamesus*). Other species may be used if these species are not available at the time when testing takes place. The echinoderm fertilization test is an EPA-approved method (EPA/600/R-95/136).

If the initial toxicity screening test indicates the effluent response is above the toxicity threshold or if discharges exceed 10,000 gallons in a 24-hour period and if chemicals are added to the system, additional WET will be conducted following established EPA methods as described in section 3.2.1 of this document. The methods for WET testing, which include seven-day Topsmelt larval and survival growth test, seven-day Mysid shrimp survival, growth, and fecundity test, and a 72-hour Purple sea urchin larval survival and development test, are well established (EPA-821-R-02-013 and EPA/600/R-95-136). Additionally, EPA SOPs already exist for each test. Thus the toxicity thresholds associated with all of the WET testing components are already defined by these existing, validated methodologies. Additional information and detail on WET testing can be found in the project-specific QAPP.

3.2.2. Water-based Drilling Fluids and Drill-Cuttings (Discharge 001) and Non-contact Cooling Water (Discharge 009) – Marine Mammal Deflections

3.2.2.1. Marine Mammal Monitoring Program Overview

Shell operates an extensive integrated marine mammal monitoring program in compliance with the Marine Mammal Protection Act (MMPA) during all exploration activities [1]. In accordance with the MMPA, applicants for an Incidental Harassment Authorization (IHA) or Letter of Authorization (LOA) from the trustee agencies, the National Marine Fisheries Service and U.S. Fish and Wildlife Service, are required to develop and implement a monitoring and mitigation plan. The agencies evaluate these plans through a process of independent peer review and public review prior to authorizing proposed activities. Although the IHA and LOA that will cover proposed 2015 drilling operations along with the associated monitoring program is not yet available, it is anticipated that the monitoring program will be effectively the same as that implemented in 2012.

A full description of this program and results from 2012 can be found at http://www.nmfs.noaa.gov/pr/pdfs/permits/shell_90dayreport_draft2012.pdf.

In summary, the Shell monitoring and mitigation program includes three integrated components:

1. A vessel-based observer program under which protected species observers (PSOs) on all vessels maintains watch for marine mammals. The PSOs have dual duties to implement any needed avoidance or mitigation measures and to record data on observations, including species type, location, behavioral activity, and orientation toward drilling activities.
2. An aerial based program under which digital imagery is collected over the area of drilling activities to assess the distribution of marine mammals during different operational periods; and
3. An acoustic program under which industry sounds and marine mammal calls are recorded and can be analyzed for distribution and reaction to drilling related activities.

This integrated program, particularly the aerial and vessel-based components, provides a good understanding of the relative distribution of marine mammals in proximity to drilling related activities, and the portion of the population of each species that could potentially be within a range of exposure to drilling related discharges. Correlation of the marine mammal distribution data with records of discharge timing and location should allow for assessment of whether

[1]The primary regulation of activities related to marine mammals is the responsibility of the National Marine Fisheries Service (NMFS) and the Fish and Wildlife Service (FWS). Shell's marine mammal monitoring program as outlined herein, or referenced in other locations, is being supplied as part of the requirement for an Environmental Monitoring Program, specifically sections II.13.g.2 and j.4 associated with non-contact cooling water, drilling fluids and drilling muds as outlined in General Permit AKG-28-8100. The submittal of this program is in order to meet the requirements associated with those permit sections, specifically having to do with marine mammal observations during those times of discharge only. Program submittal, nor any reporting provided to EPA as a result of the program, does not act to confer on, or subject the program to, EPA jurisdiction outside of those specific areas, and/or in conflict with any jurisdiction by NMFS or FWS.

changes in marine mammal behavior related to drilling related discharges can be detected. It should be recognized, however, that discharge of drilling fluids/cuttings (D001) and non-contact cooling water (D009) is only one of several factors (e.g. sound, proximity of other vessels, and non-anthropogenic variables) that may contribute to, or independently cause, such perceived reactions. Additionally, the area affected by the discharges will be smaller than those from several of the other drilling related factors that might influence behavior. In particular, the propagation of underwater sound from the drilling and related activities has been shown to cause behavioral reactions in marine mammals, including avoidance (Richardson et al. 1995).

Some species of marine mammals, whales in particular, are known to avoid or deflect around anthropogenic disturbances in some instances. The extent to which avoidance occurs, or the size of the effect zone associated with the activity, typically depends on a combination of factors rather than a single, isolated variable (LGL et al. 2014). Marine mammal behavioral reactions to anthropogenic activities can be influenced by factors including underwater sound levels, distance to the sound source or activity, behavioral state of the individual when it encounters the activity, life history stage, and proximity to a food source. Shell's marine mammal monitoring and mitigation program is designed to investigate how marine mammals react to drilling related activities; however, despite the most rigorous of monitoring methods, reactions may not always be attributable to a single cause.

As noted above, the size of the area in which marine mammals may encounter drilling-related discharges is relatively small in comparison to other potential effect zones, including the area of increased underwater sound levels from drilling activities. For example, discharge modeling (Fluid Dynamix, 2014c) estimated the concentration of total suspended solids (TSS) discharge associated with drill fluids/cuttings (D001) from the Noble Discoverer would reach concentrations of less than 15 mg/l within approximately 1,000 meters from the discharge point. Similarly, modeled (Fluid Dynamix, 2014i) estimates of the thermal plume from non-contact cooling water discharge (D013) reaches ambient water temperature within approximately 200 meters from the discharge point.

By comparison, bowhead whales have been known to avoid numerous offshore Arctic drilling operations at distances of 10 to 20 kilometers. These documented avoidances of active drilling rigs in the Beaufort Sea were largely believed to be in response to underwater sound (Richardson et al. 1985; LGL and Greeneridge 1987; NMFS 2008). Therefore, the potential effect zones from drilling related sounds are considerably larger compared to those from discharged muds/cuttings or thermal plumes, and may actually preclude the potential for marine mammals to encounter a discharge plume and exhibit an avoidance reaction to it. Nonetheless, Shell will collect several data streams, described below, that will be useful for assessing whether drilling related discharges can be correlated with any such deflection behavior.

3.2.2.2. Vessel-Based Monitoring

The visual monitoring methods that are employed during vessel based monitoring are similar to those used during geophysical marine surveys in 2006-2013 and to those employed during drilling related monitoring in 2012. PSOs are typically stationed on the bridge or from a position on the vessel that allows safety and effects zones (also referred to as disturbance zones) to be monitored for marine mammals. PSOs are on active watch during nearly all daylight periods and during the night if required. Depending on the vessel, watches are conducted with the unaided eye and/or specialized monitoring equipment. For each marine mammal sighting, specific information (e.g. species, behavior, heading, reaction,) is recorded. All marine mammal sightings are recorded by PSOs, regardless of vessel activity or status of the drilling operation. Environmental effort data (ship's position, sea state, ice cover, visibility) is also collected. Effort data are recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables. Figure 6, which illustrates the distribution and relative amount of vessel-based PSO monitoring effort from Shell's 2012 Chukchi Sea drilling program, shows intensive monitoring effort at and directly adjacent to the drill site. PSOs on the EMP vessel(s), as part of their duties, will record the presence and behavior of any encountered marine mammals in the vicinity of the drill rig.

Vessel-based PSO data will be analyzed following the end of the drilling season to isolate periods that correspond with discharge activities. The analysis will involve a comparison of marine mammal distribution data from periods with and without discharges to look for potential avoidance/deflection during times of discharge. Data collected by PSOs aboard the dedicated EMP vessel in the vicinity of the discharge plume will be valuable for comparing marine mammal distribution between periods of discharge and no discharge, particularly for seals as they are observed frequently near vessels and drill rigs.

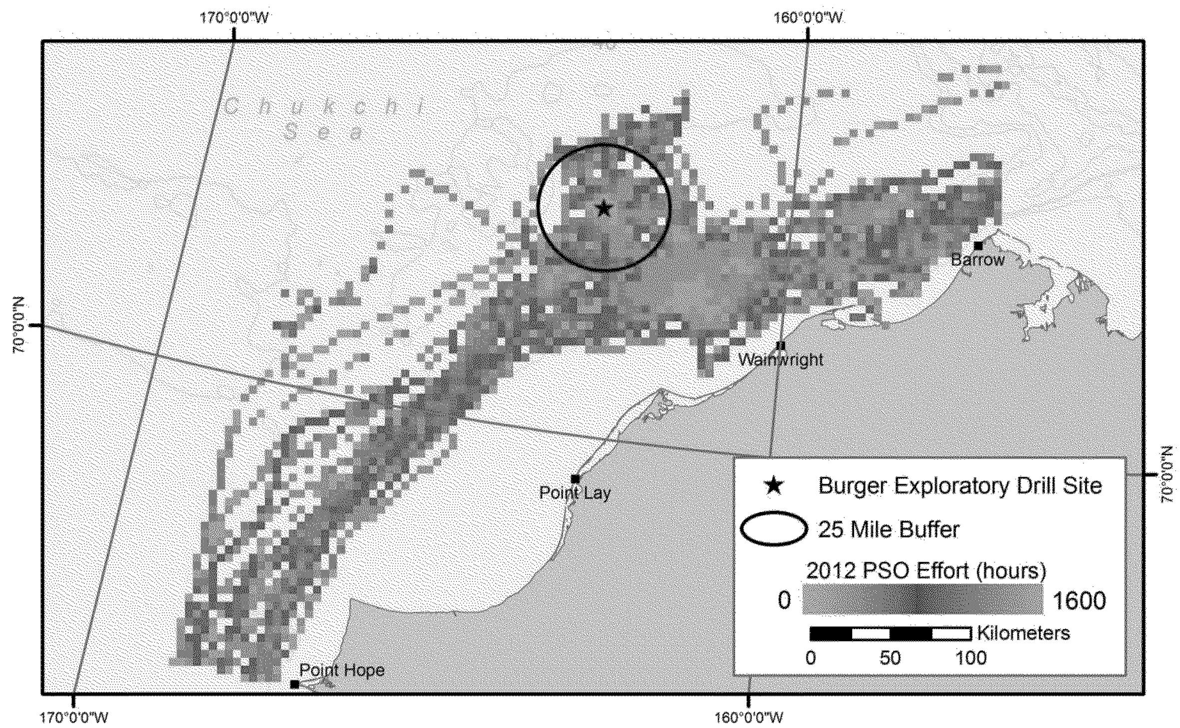

Figure 6: Distribution and amount (in hours) of vessel-based PSO monitoring during Shell's 2012 Chukchi Sea exploratory drilling program. Areas of intensive monitoring included the drill site and discharge location, transit routes, and a standby location between the drill site and Wainwright.

3.2.2.3. Aerial-Based Monitoring

Aerial surveys of marine mammals in the Chukchi and Beaufort seas were conducted in 2006–2008, 2010 and 2012 in support of the exploration programs. The aerial survey component is designed to provide a systematic assessment of the distribution of marine mammals in areas within and adjacent to drilling operations. Of particular interest is an assessment of bowhead whales during their annual fall migration through the Beaufort Sea and Chukchi Sea, and also beluga whale and Pacific walrus distributions throughout the survey area. The specific objectives are to:

- Collect and report data on the distribution, number, movement and behavior of marine mammals near the exploration operations with special emphasis on migrating bowhead whales;
- Support regulatory reporting requirements related to the estimation of impacts of exploration activities on marine mammals; and
- Investigate potential deflection of bowhead whales during migration by documenting how far from exploration activities a potential deflection may occur, and where and when whales return to normal migration patterns.

High-definition digital still and video cameras are installed aboard survey aircraft for use during flights. Aerial photographic surveys using these cameras and high-definition video are flown by a pilot and co-pilot over the Burger prospect area in the Chukchi Sea. The incorporation of marine mammal sightings data from digital imagery is part of ongoing efforts to develop and validate technology for use in unmanned aerial systems in future years.

The offshore survey grid is designed to cover a circular area with a radius of 45 km (28 mi) around the exploratory drill site as shown in Figure 7. Transect spacing is stratified to maximize coverage in potential effect zones, including areas where drilling related discharges will occur. Intensive sampling over a potential effect zone increases the likelihood of being able to detect such an effect if one exists or occurs. The spacing of the outer survey lines is 10 km (6.2 mi) and the spacing between the intensive lines is 5 km (3.1 mi; Figure 7). Total length of the photographic survey transects is approximately 1000 km (621 mi) and the exact length depends on the location of a randomly selected start point. Still cameras on each side of the aircraft take a photograph once every three seconds, which results in a total of approximately 12,000 images per survey.

Aerial photographic data will be filtered and analyzed in much the same fashion as vessel-based PSO data described above to assess the potential for avoidance/deflection of drilling related discharges by marine mammals. Plume discharge may be detectable in the photographic images. Such images will be pooled with those taken in surrounding areas and also with vessel-based PSO observations from the same time periods. A comparison of the marine mammal distributions during periods with and without discharge plumes present in the images will contribute to assessing whether drilling related plumes correlate with localized avoidance associated with drilling operations.

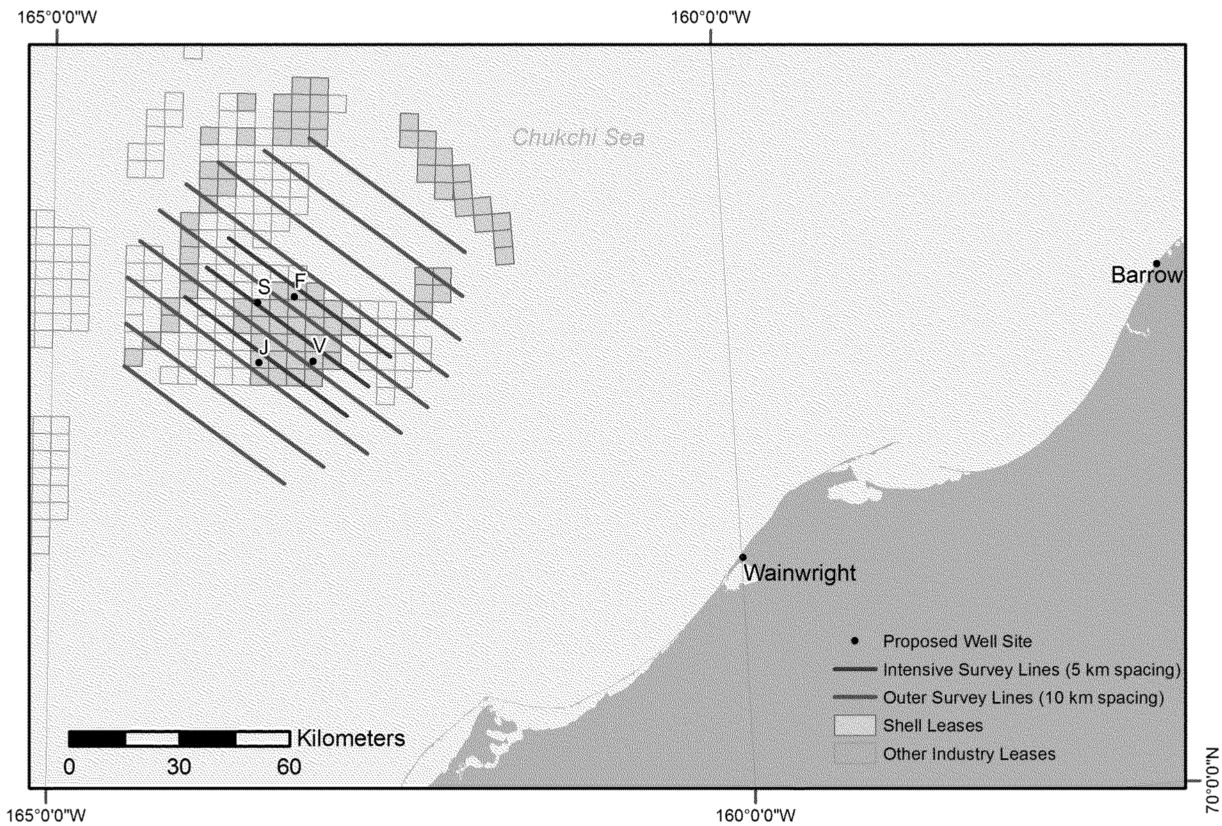

Figure 7: Offshore aerial photographic survey transect locations and general survey pattern for the eastern Chukchi Sea. Stratified sampling with intensive survey effort over the well sites is designed to investigate potential impacts (effect zones) to marine mammals from activities at or near drilling locations, including discharge plumes.

3.2.2.4. Acoustic Monitoring

The large-scale acoustics program in the Chukchi Sea employs aut onomous acoustic recording systems deployed on the seabed for extended periods over large are as of the northeastern Chukchi Sea. An acoustic "net" array, used since 2006, is designed to acc omplish two main objectives:

1. Collect information on the occurrence and distribution of marine mammal s (including beluga whale, bowhead whale, and walrus) that may be available to subsistence hunters near villages located on the Chukchi Sea coast and to document their re lative abundance, habitat use, and migratory patterns; and
2. Measure the ambient sound levels throughout the northeastern Chukchi Sea and to record levels of sounds from industry and other activities further offshore in the Chukchi Sea.

The recorders operate at a sampling frequency of 16 kilohertz to capt ure vocalizations from bowhead, beluga, gray, fin, humpback, and killer whales, as well as walr uses, seals, and most other marine mammals known to be present in the Chukchi Sea. Over-wint er recorders have been deployed in the Chukchi Sea since 2008 at five sites to monitor late fall, winter and spring distributions of marine mammals.

During the 2012 drill season, acoustic data were acquired with 31 Autonomous Multichannel Acoustic Recorders (AMARs) deployed from early August through mid-October throughout the northeastern Chukchi Sea. Twenty-two AMARs were deployed in a regional array along four lines extending offshore from Cape Lisburne, Point Lay, Wainwright and Barrow (Figure 8). The drill location was surrounded by seven AMARs.

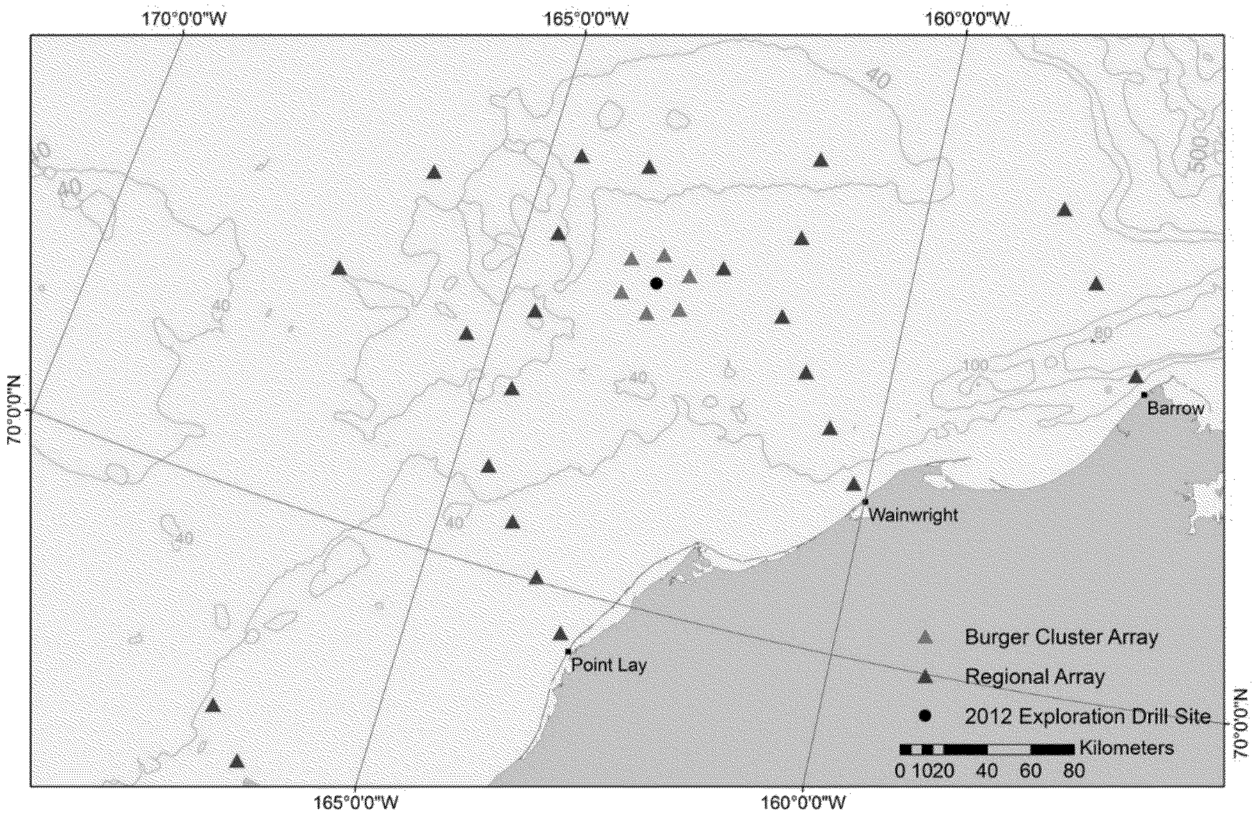

Figure 8: Deployment locations of hydrophones in acoustic arrays in the eastern Chukchi Sea, Alaska 2012**.**

The acquired acoustic data were then analyzed to quantify ambient sound levels, presence of anthropogenic activity (such as vessels and drilling sounds), and the acoustic presence of marine mammals.

Analysis of acoustic data from arrays in the Chukchi Sea addresses the following questions:

1. Determined when, where and what species of animals are acoustically detected on each recorder;
2. Analyzed data as a whole to determine offshore distributions as a function of time;
3. Quantified spatial and temporal variability in the ambient sound levels; and
4. Measured sound levels of exploration activity events.

The detection data are used to develop spatial and temporal animal detection distributions as a function of different variables (e.g., time of day, season, environmental conditions, and ambient sound energy and vessel sound levels). The spatial resolution of acoustic data in the Chukchi Sea around Shell's drilling program is not designed to detect potential small-scale changes in the distribution of vocalizing marine mammals around a discharge plume; however, these data are extremely important for interpreting the broad scale distribution patterns of marine mammals when integrated with aerial and vessel-based observations.

3.2.3. Water-Based Drilling-fluids/Drill-Cuttings: Metals and Hydrocarbon Analysis

Samples of water-based drilling fluids and drill-cuttings will be collected during the drilling operations at two intervals (discussed in Section 3.2.4) by a compliance engineer stationed on the drilling rig, and then transported to an analytical laboratory to be analyzed for metals and hydrocarbons.

Although only metals analyses are required in Permit No.: AKG-28 -8100, hydrocarbon analyses will also be conducted on water-based drilling fluids and drill-cuttings to understand source loading that will inform data analysis components in the post-drilling phases (Phases III and IV). Hydrocarbons are not typically present in water-based drilling fluids, but may become entrained in drilling fluids when drilling through a hydrocarbon zone occurs.

3.2.4. Plume Monitoring and Observations

3.2.4.1. Primary Sampling Time Periods

The objective of the plume-monitoring component is to measure metals, organics, turbidity and total suspended solids throughout the water column during periods of maximum discharge of water-based drilling fluid and drill-cuttings (D001). Additionally, the objective is to focus characterization efforts on areas of expected deposition of water-based drilling fluid and drill-cuttings based on model predictions. Plume monitoring will also serve as a check/verification of modeled effluent behavior.

Phase II plume monitoring will be conducted from a vessel configured to conduct environmental monitoring. Safety, operational and navigational issues could limit the ability to delineate plume(s) in the immediate vicinity of the drilling operations. Within these logistical constraints, efforts will be made to safely locate and sample the plume(s) during the drilling process. In order to assess potential maximum discharge of metals, hydrocarbons, turbidity, and total suspended solids, two primary time periods will be targeted.

(1) Drilling of the largest casing interval after the BOP stack is set (identified as drilling interval four in the modeling reports); this time period represents the expected maximum discharge rate over the longest time interval of water-based drilling fluids and drill-cuttings during the drilling process.

(2) During and/or immediately following bulk-drilling fluid discharge; this discharge represents a period when only water-based drilling fluid (with some finer entrained

drill-cuttings) is discharged and total suspended solids could be higher due to the small particle size of the material (barite and bentonite).

Every effort will be made to safely collect samples within the plume during the Phase II primary time periods specified above. In the event circumstances arise that would prevent sample collection, contingency options have been developed to replace the collection of any samples which are not possible to obtain during the primary time periods. In the event that sea state, weather, ice, a medical emergency, or other unforeseen factors are encountered, and to confirm compliance with Permit No.: AKG-28-8100; the following will be implemented as secondary options for the two primary time periods.

(1) Drilling in the largest casing interval;

   a. If sampling during the largest casing interval is not possible or cannot be entirely conducted within this interval, the next lower casing interval will be sampled. If unforeseen circumstances prevent sample collection exclusively within this substitute interval, the next casing interval that can be sampled will be utilized. The details of the drilling volumes will be recorded throughout all drilling intervals so a comparison can be made.

   b. In the event that 1(a) cannot be achieved, source sampling and modeling will be used to verify compliance with the objectives specified in Permit No.: AKG-28-8100. A source sample of the water-based drilling fluid and drill-cuttings prior to discharge from the rig will be collected. In conjunction with real time meteorological conditions (e.g., current direction and speed), modeling will then be performed to provide an estimate of the plume location and concentration of constituents in the water column.

   c. In the event that 1(a) or 1(b) cannot be achieved, data from any other similarly designed well(s) drilled at the Burger Prospect will be used to compare modeling results from that well.

(2) During and/or immediately following bulk-drilling fluid discharge;

   a. In the event that sampling is unable to occur, a source sample of drilling fluid prior to discharge from the rig will be collected. In conjunction with real time meteorological conditions (e.g., current direction and speed), modeling will be performed to provide an estimate of the plume location and concentration of constituents in the water column.

   b. In the event that 2(a) cannot be achieved, data from any other similarly designed well(s) drilled at the Burger Prospect will be used to perform modeling.

The data collected during Phase II of the EMP will be used in conjunction with data that will be collected from samples taken on the drilling rigs, including analytical data from water-based drilling fluids and drill-cuttings samples as well as operational activity logs. These data, taken together, allow for a substantial dataset to inform the Phase II data analysis.

3.2.4.2. Sample Locations and Plume Tracking

An illustration of the Phase II plume sampling stations is provided in Figure 9. Note that the predominant current arrow indicated on the figure is to show that samples will be collected in the direction of current flow. Actual current direction and velocity will be measured in real time through the use of ship-mounted ADCP. Up to seven sampling stations will be targeted for sample collection during the two periods of maximum discharge. One sampling station will serve as a reference station and be located at least 1,000 m away and perpendicular to the downstream plume transect. The other stations (up to six) will be located along three transects (two stations per transect) oriented in the direction of the predominant current. The three plume transects will be separated approximately 10-15 degrees, as conditions warrant, from the discharge source. All plume-transect sampling stations will be located near the drilling location, with the near-field stations being as close to the discharge as logistically possible, while maintaining a minimum 500 m safety zone from the drill rig.

The geometry of a discharge plume is directly influenced by the ambient meteorological and physical oceanographic conditions in the vicinity of the well site. Current speeds and turbulent mixing at different depths in the water-column can have a substantial effect on the dispersion and deposition rates of discharge-associated solids. Currents within the area of the drill rig should be horizontally coherent, (i.e. same current velocity over linear distance, over distances of 10 to 20 kilometers) (T. Weingartner, personal communication); therefore, the location of the water-based drilling fluid and drill-cuttings plumes will be tracked by using water column velocity data from an ADCP and a deployable water column profiler. An ADCP with real time or near-real time data-transfer capability will be located on, or in the vicinity of, the drill rig and on the monitoring vessel to provide information on currents. Water column velocity data from the ADCP will be used in near-real time to coordinate the deployment of a water column profiler, a Sea-Bird Electronics, Inc., SBE19 (or equivalent) conductivity, temperature, depth (CTD) unit equipped with a turbidity sensor (e.g., optical backscatter (OBS)) and a transmissometer. Data from the turbidity sensors, indicating potential discharge of suspended solids, will be used to obtain near-real time multi-dimensional data on water column conditions. Weather data will be acquired in the field to further inform sampling activities.

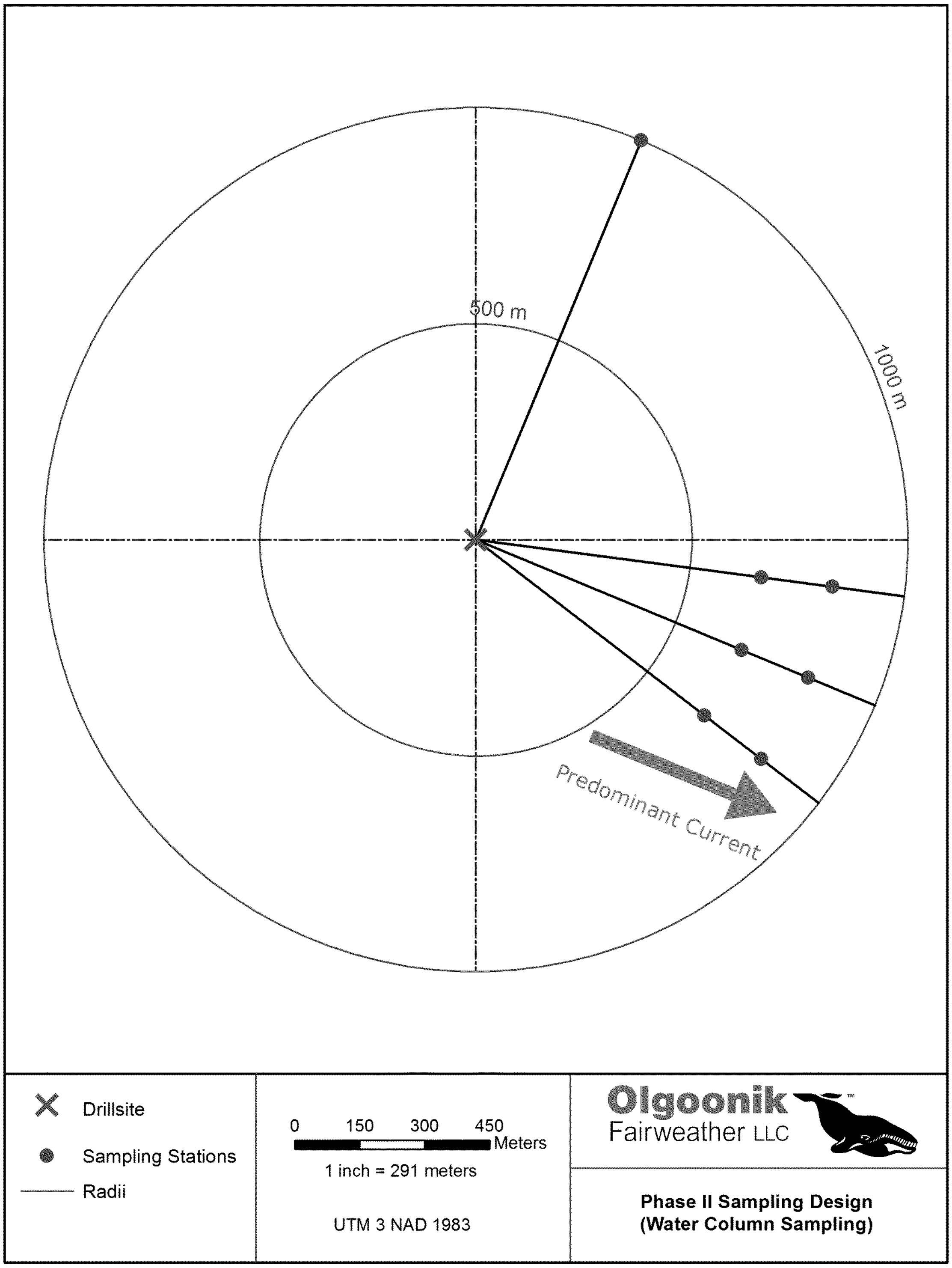

Figure 9: Representative sampling stations for Phase II (water column sampling). Specific station locations will be based on actual site data and will be determined in the field.

3.2.4.3. Sample Collection

The CTD unit includes a multiple bottle rosette to collect discrete water samples. Samples will be attempted for collection at five different depths in the water column. General target sample depths are approximately 1 m (near-surface), 10 m, 20 m and 30 m below the surface of the water, and 2 m above the bottom of the seafloor. The near-real time current data from the ADCP and the near-real time water column data from the CTD profiler will be used to optimize the location and depth for discrete water sample collection in order to capture the greatest particle concentration portion of the plume, when possible. Water samples will be collected for the following parameters: metals, total suspended solids (TSS) and organics (volatile organic compounds [VOC], total aromatic hydrocarbons [TAH] including xylenes, total petroleum hydrocarbons [TPH], polycyclic aromatic hydrocarbons [PAH], and saturated hydrocarbons [SHC]). Specific analytes and analytical methods are included in the project-specific QAPP. Turbidity measurements in the water-column will be collected with a turbidity sensor (e.g., OBS) and a transmissometer with the CTD attached to the water-sampling rosette.

A summary of the Phase II sampling effort is provided in Table 7. Field observations and/or analytical data collected during the Phase II monitoring will be used to assess the location of the plume(s), to refine model inputs, and to help inform the Phase III and IV monitoring efforts, respectively. Data from Phase II efforts will also be compared to the chemical analysis results from source samples collected on the drilling rigs (such as drilling fluids and drill-cuttings), and if appropriate, may be used to augment the Phase II data collected.

Table 7: Summary of Phase II sampling. Total number of samples over all monitoring intervals is up to 70 (35x2) for water sampling and up to 6 for water-based drilling fluid and drill-cuttings.

Sampling Water Depth[1]	Transect Type	Number of Samples (Estimated)		
		Phase – Largest Casing Interval	Phase – Bulk Drilling Fluids[2]	Total Number of Samples
1 m below surface	Plume	6	6	12
	Reference	1	1	2
10 m below surface	Plume	6	6	12
	Reference	1	1	2
20 m below surface	Plume	6	6	12
	Reference	1	1	2
30 m below surface	Plume	6	6	12
	Reference	1	1	2
2 m above bottom	Plume	6	6	12
	Reference	1	1	2
Drill-Cuttings	Drilling Rig	2	0[3]	2
Drilling Fluid	Drilling Rig	2	2	4
Subtotal		**Up to 39**	**Up to 37**	**Up to 76**

[1]Sampling water depth may vary depending on in-field measurements of turbidity during plume monitoring, weather conditions, or operational parameters
[2]If bulk discharge event occurs
[3]No separate drill-cuttings samples will be collected because they are not present at significant concentrations in the bulk drilling fluids.

3.3. Phase III and Phase IV Assessment

The objective of the Phase III assessment is to assess the drilling site seabed condition immediately after drilling is completed. This assessment is designed such that the information collected can be used to refine predictions of extent of coverage and thickness of water-based drilling fluid and drill-cuttings on the sea floor. This information will be compared with results from the subsequent Phase IV assessment.

The purpose of the Phase IV assessment is to evaluate conditions of the benthic environment over time. The assessment will occur no later than 15 months after drilling operations cease at a drilling site and will follow the same sampling design (described below) used for the Phase III assessment. The same types of samples will be collected in Phase IV as in Phase III, at approximately the same locations, and collection of the same numbers of samples will be targeted. However, to measure any potential long-term impacts to the benthic community as a result of exploratory drilling operations, benthic sampling will be added as part of the Phase IV assessment.

3.3.1. Sampling Design (Phase III and IV)

A four-transect sampling design (N, E, S and W) off-set 22.5 degrees in line with the annual mean current direction will be used unless indicated otherwise by field observations. This standardized environmental monitoring design, which is used for both oil and gas exploratory drilling activities and production operations, is a four by four transect/radii design in which the sampling stations are placed at increasing distances from the center (e.g. drill site) and one axis is located along the dominant annual mean current direction (Olsgard et al . 1995). Sample stations along the transects will be located at four different radii of 100 m, 250 m, 500 m, and 1000 m from the drill site location (Figure 10). This sampling design results in a total of 17 stations, 16 of which are determined from each intersection of the four transects with each of the four radii. The 17th sampling station will be in the vicinity of the actual drill site location. For purpose of this sampling design, these will be defined as sample-design near-field stations.

The transect/radii sampling design proposed for Phase III and IV assessment has been used extensively in the Atlantic Ocean (e.g., Georges Bank region [Neff et al. 1989]), the North Sea (e.g., Norwegian oil exploration and production at Ecofisk, Eldfisk, and other Norwegian oil fields [Gray et al. 1990, Olsgard and Gray 1995, Gray et al. 1999, Iversen et al. 2011, The Research Council of Norway 2012]), and in the Gulf of Mexico (e.g., Gettleson et al. 1981). Ellis and Schneider (1997), building off the work done by others (e.g., Gray, Hurlbert, and Underwood), demonstrated that a gradient sampling design is more powerful than a randomized control/impact sampling design (e.g., analyzing randomly placed "impacted" areas vs. "control" areas). The gradient approach has been shown to allow for an improved distinction between natural variability and putative anthropogenic effects (Ellis and Schneider 1997).

A review of the literature on environmental monitoring of exploratory drilling using water-based drilling fluid indicates the majority of impacts, including chemical, physical and biological, from wells drilled in water depths less than 200 m occur within 500 m from the drill site (Ellis and Schneider 1997, The Research Council of Norway 2012, Trefry et al. 2013). OOC Modeling conducted for the purpose of designing the EMP plan of study, as discussed in Section 2.2.4.1, indicates this should also be the case for the drilling operations at the Burger prospect. Consequently, 13 of the 17 (76%) near-field sampling stations are located within 500 m of the well location. By design, there is overlap of the plume-monitoring transect (Figure 9) for Phase II with that of the 112.5 degree transect line (Figure 10) for the Phase III and IV sampling design.

Although the OOC Model results predict deposition from water-based drilling fluid and drill-cuttings in the predominant current direction and within a bound of approximately 500 m from the drill site, it will not be solely relied upon for determining the Phase III and IV sampling locations. The OOC Model does not incorporate all discrete parameters over time that can influence discharge deposition. For example, the water currents in the Chukchi Sea can be variable and may frequently change direction (Weingartner et al. 2005, Weingartner et al. 2011). Similarly, due to the relatively shallow water depths in the Chukchi Sea, currents may be wind-driven during storm events, which can also result in currents that are different from the statistical averages. Changes in current directions and velocities, beyond the mean and max predominant current modeled, may result in deposition(s) that are not homogeneous along the anticipated average current direction. Unlike the drilling monitoring as part of the Phase II assessment, which is reliant on real time water current directions and velocities, the post-drilling monitoring is dependent on factors such as sediment re-suspension and re-deposition, which can result in modified spatial and temporal depositional footprints.

Sampling closer than 100 m from the drill site is challenging because the research monitoring vessel itself is likely to be more than 60 m long. Sampling biota in this small of an area is particularly challenging because the stations are no longer distinct (e.g., 2-4 minute clam rake tows are not representative of a single station at 25-50 m from the drill site).

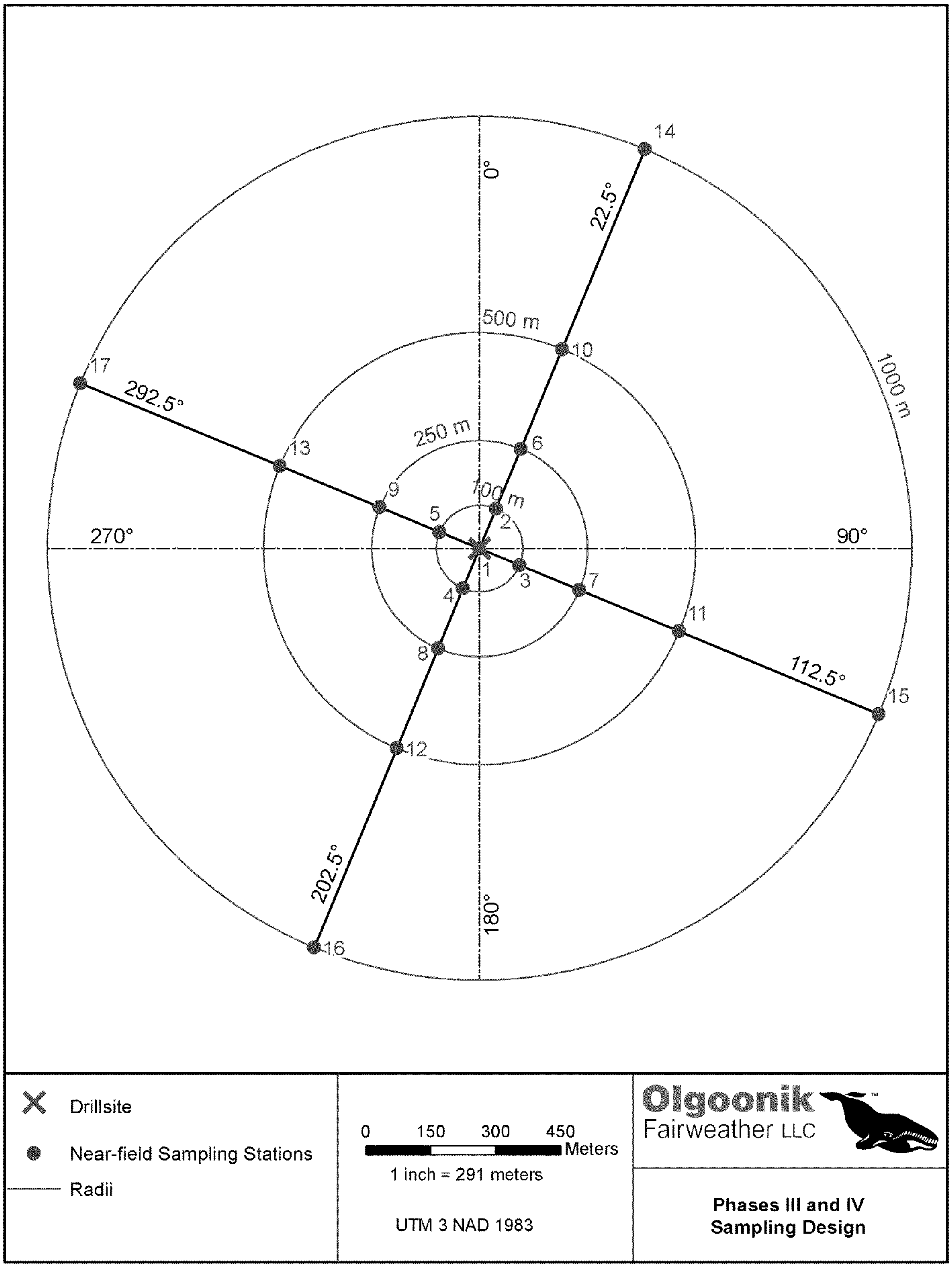

Figure 10: Phases III and IV sampling design (seafloor sampling).

3.3.2. Initiation of Phase III Sampling

Completion of well drilling will likely not conclude until late September or early October. Delays in beginning of the drilling season or other unforeseen circumstances may result in the drilling of only a portion of the well. Phase III assessment will be initiated when End of Well is achieved. End of Well is defined, for purposes of sampling drilling fluid and drill-cuttings, at the location where the drill bit is at least 80% of the final well footage (Permit No.: AKG 28-8100, Section VII. Definitions, p. 74). Therefore, the Phase III assessment will not be initiated until after the well is drilled past 80% of PTD. In the event any other unforeseen circumstances occur preventing environmental sampling of data immediately after drilling, Shell will immediately notify EPA in accordance with Permit No.: AKG-28-8100 Section II.A.13.h.2, and the appropriate course of action will be determined.

3.3.3. Assessment Components (Phase III and IV)

Samples collected during Phase III will consist of sediment for chemical and physical analyses, clam tissues for chemical analysis, and digital SPI photographs of cross-sections of the sediment-water interface (Table 8). Phase IV assessment will include benthic community sampling in addition to Phase III components. Sample methods for each component are described below. Far-field stations will be determined based on Phase II data for plume deposition(s) to ensure reference stations are well outside any areas potentially impacted by deposition of drilling fluid and drill-cuttings. Where possible, some far-field stations will be intentionally located at stations previously sampled in prior studies (e.g., CSESP) to allow for long-term data collection at stations for which data exist since 2008. This allows for reference locations outside the potential impact area(s) (i.e., anthropogenic-specific monitoring) as well as data collection from stations outside the potential impact area(s) that have existing data for long-term monitoring (i.e., changes as a result of natural variability).

Table 8: Summary of Near-Field[1] and Far-Field Phase III and Phase IV samples slated for collection.

Discipline	Number of Sample Design Near-field stations	Number of Far-Field[1] stations	Number of samples
Sediment Profile Imagery	Up to 17	Up to 2-4	Up to 19-21[2]
Benthic ecology (Phase IV only)	Up to 17	Up to 2-4	Up to 57-63 (3 reps, possibly 5 reps, depending on field conditions and operational limitations)
Chemistry—sediments	Up to 17	Up to 2-4	Up to 19-21
Chemistry—biota (clams)	Up to 4	Up to 1-2	Up to 5-6
Chemistry—biota (amphipods)	Up to 4	Up to 1-2	Up to 5-6

[1] Far-field samples will be collected at 2-4 stations contemporaneous with the near-field stations. Far-field stations will be consistent with a subset of stations from the CSESP, where possible.
[2] Multiple photographs will be taken at each station (plan-view and cross-sectional) to ensure at least one high-quality photograph per station.

3.3.4. Physical Sea-bottom Survey (Phase III and IV)

Plan-view digital photographs of the seabed and profile digital photographs of the sediment–water interface will be obtained with SPI technology and/or other similar technology such as a camera-sled or ROV. In the event that a camera-sled or ROV is used to collect the images, they will be plan-view photographs only. Images will be assessed to characterize seabed conditions immediately (as soon as practicable) after completion of the drilling operations. SPI technology involves the use of submersible digital camera equipment to penetrate and acquire vertical-profile photographs of the upper 10-20 cm of the seabed sediment that can be analyzed for a variety of physical, chemical and biological parameters. A secondary camera is used to obtain plan-view images of the seabed surface. ROV and camera-sled technologies use submersible cameras to obtain images of the seabed surface.

Data from the plan-view photographs will be used to characterize the spatial extent and depth/thickness of solids deposition as a result of water-based drilling fluid and drill-cuttings discharges (D001), excess cement slurry (D012), and muds, cuttings, and cement at the seabed (D013). In the event that SPI is used, the addition of the profile photographs can facilitate in situ observations at and between benthic-sampling stations, thereby increasing the ability to characterize horizontal and vertical impacts on the benthic habitat. During the post-drill surveys, photographic data will be collected at up to 17 sample-design near-field stations.

3.3.5. Sediment Characteristics and Discharge Effects (Phase III and IV)

Sampling will be conducted at up to 17 near-field stations to evaluate chemical and physical sediment characteristics following drilling activities and to determine the lateral extent of deposition of water-based drilling fluid and drill-cuttings. The thickness of the depositions on the seafloor will also be measured via photographic evidence (Section 3.3.1) in conjunction with sediment sampling (e.g., van Veen grabs). Based on the knowledge of chemicals associated with drilling operations (and on Permit No.: AKG-28-8100 requirements), the focus for this study will include analysis of organics, metals, total organic carbon (TOC), and grain-size distributions.

3.3.6. Sediment Chemistry Monitoring (Phase III and IV)

Organic constituents for analysis will include PAH, TPH, SHC and petroleum biomarkers. These compounds are consistent with the list of organic chemicals analyzed in the 2008 characterization study in the Chukchi Sea and the 2012 baseline monitoring at the Burger A drill site (see Appendix A) allowing for consistent comparison with the baseline sediment-chemistry data from previous studies. Metals and hydrocarbons for analysis in sediments are listed in the project-specific QAPP. Sediment chemical concentrations from Phase III will be compared with existing baseline data and with the source samples (drilling fluids and drill-cuttings collected during Phase II monitoring) for a comprehensive post-activity evaluation and analysis in the EMP Report #1. Following Phase IV monitoring, further data comparisons will be made and presented in the EMP Report #2.

3.3.7. Benthic Community Bioaccumulation Monitoring (Phase III and IV)

Targeted biota for collection for chemical analysis includes clam tissues (benthic) and amphipods (epibenthic). Both clams and amphipods are important infauna and epibenthic invertebrate species, respectively, in the Arctic food web (Dunton et al. 2012a). In the Arctic (as well as elsewhere), clams are typically representative of lower (2-2.4) trophic levels (Dunton et al. 2012a) and are good indicator species for measuring bioaccumulation from benthic exposure because they are filter feeders, benthic omnivores, and/or deposit/subsurface feeders (depending on the particular species), relatively sessile, and do not typically possess the enzyme systems for metabolizing hydrocarbons (Neff 2010, Dunton et al 2012). Clams are an important food source for walrus and some seal species that feed in the benthic environment. Amphipods, which are primary food for grey whales depending on the particular species, typically fall in a higher trophic level than benthic clams (e.g., trophic level 2.8-3.9 in the Alaskan Beaufort Sea), and inhabit the epibenthos (Dunton et al. 2012a). Methods of collection for both types of targeted biota will be similar to those used previously in CSESP (Neff 2002), other Arctic programs (Neff and Durell 2011) and COMIDA-CAB (Dunton et al. 2012b).

3.3.7.1. Benthic Clams

An attempt will be made to collect clam samples at four of the stations where sediment samples and samples for benthic community-structure evaluations (in Phase IV) are also sampled, initially targeting stations along the transect that represents the average current direction (e.g., stations 3,7,11, and 15 in Figure 10). Due to natural patchiness and variability in abundance of these larger infaunal organisms, it is particularly challenging to collect adequate sample biomass at a pre-determined station. Clam collection will be attempted using a combination of double van Veen grab and towed clam rake. The sediment remaining following sediment sample collection for chemical analysis using the double van Veen grab sampler, will be sieved through a coarse sieve (1” mesh) to gather clams. Previous work done in the CSESP program to collect clams for chemical analysis have demonstrated better success using a towed clam rake than using the van Veen grab. The clam rake consists of a stainless steel pronged rake with a Vexar-net attached to “catch” material as the rake is dragged through the sediment. The Vexar-net has approximately one quarter inch holes that allow for water to pass through while the solid materials (including biological materials) are retained in the net. The clam rake is deployed from the monitoring vessel using a crane or A-frame (or similar) and a winch/block system. When the rake reaches the sediment-water interface, it is towed at approximately 2 knots for a few minutes to cover a lineal distance of ~30 m per on-bottom time minute. Samples will be targeted at the specific defined stations, rather than towed along a transect. The rake is towed around a station in a circle or semi-circle (to the degree possible, depending on weather/sea state). This can present challenges for the stations in close proximity to the drill site. Typically the duration of the tow is determined in the field depending on the “haul” that is obtained following the first few tows. At the cessation of the tow, the rake is returned to the vessel via the winch/block system and the haul is collected into clean, plastic tubs for sorting. A typical area towed represents approximately 150-200 m^2.

Ideally, samples will represent composited single clam species (not individuals; clams are typically not large enough in size in the Chukchi Sea to provide enough tissue mass for chemical analysis). When tissue mass is limited, multiple species of clams may be composited from a single station to ensure adequate tissue mass for chemical analysis. Previous studies, using nitrogen isotope ratio analysis for the clams to be potentially collected, indicate they are all very similar in trophic position (Dunton et al. 2012a). Higher level organisms such as crabs, polychaete worms, and fish will not be attempted for collection for tissue analysis because these organisms metabolize, and thus do not bioaccumulate, polycyclic aromatic hydrocarbons (e.g., Driscoll and McElroy 1996, Forbes et al. 2001).

3.3.7.2. Epibenthic Amphipods

An attempt will be made to collect amphipod samples at four of the stations where clams are also sampled, initially targeting the same stations along the transect that represents the average current direction (e.g., stations 3,7,11 and 15 in Figure 10). Due to natural patchiness and variability in abundance of organisms, it is particularly challenging to collect adequate sample sizes at pre-determined stations for some of the targeted species.

Amphipods will be sampled using baited modified minnow-traps deployed at the target stations. Traps are lined with Nytex mesh (to minimize loss of any amphipods in the traps upon retrieval), baited, attached to a long-line and anchor weight and deployed off the monitoring vessel. Traps are soaked for 8-12 hours (approximate time dependent on monitoring vessel logistics and weather/sea state) and retrieved using a grappling hook. Upon retrieval, the amphipods are transferred from the traps to a clean, fine mesh sieve, and thoroughly rinsed. Ideally, samples will represent composited single amphipod species of hundreds of individuals. However, when tissue mass is limited, multiple species of amphipods may be composited from a single station to ensure adequate tissue mass for chemical analysis.

3.3.8. Benthic Community Structure (Phase IV only)

Benthic invertebrate communities are a key component in the Chukchi Sea food web, providing benthic–pelagic coupling of organic carbon from sediments to pelagic populations, including many species of marine fishes, birds and mammals. Benthic-feeding marine mammals in the Chukchi Sea include bearded and ringed seals, walruses, gray whales, and occasionally bowhead whales (Bluhm and Gradinger 2008). Walruses migrate through the Chukchi Sea and probably are the main mammalian predator on benthic bivalves and other large benthic invertebrates in the study area (Fay 1982).

Invertebrates living in sediments (infauna) are excellent indicators of disturbance of benthic communities (Boesch and Rosenberg 1981). These sediment-dwelling organisms are either sessile or unable to move large distances (relative to the scale of disturbance events). They must adjust to environmental change or disappear from the altered environment. Assessments of disturbance events usually focus on change in the community composition of benthic animals due to the differential responses of the animals to stress at individual and community levels. Benthic invertebrates will be collected for community-composition analysis by methods similar to those used in the CSESP (Blanchard et al. 2010, 2011, 2013). Photographic documentation (e.g., SPI) will provide a complementary data set to the evaluation of benthic community structure by providing the opportunity to document sediment habitat characteristics and changes in benthic faunal distributions within sediments via digital photography.

4. TECHNICAL METHODS

The following includes a summary of the field and laboratory analytical approaches. Field and laboratory components include quality assurance and quality control aspects which are critical to the integrity of the data and ensure data quality. Each field method is described briefly as an overview for each approach. Similarly, each technical method is presented as an overall summary for each analysis type. Detailed information for both the field and analytical approaches can be found in the project-specific QAPP which contains detailed information on field SOPs as well as analytical chemistry parameters (e.g., method detection limits, instrumentation, corrective action approaches, if needed) and other analytical details. Laboratory SOPs are available upon request.

4.1. Field Methods

A project-specific QAPP is presented in conjunction with this EMP document and will be used for the execution of the field program. The QAPP describes the field protocols in detail, including SOPs.

4.1.1. Collection of Phase II Samples

4.1.1.1. Effluent Samples for Toxicity Analysis

Under the Phase II Assessment, effluent samples for toxicity analysis will be collected by grab sampling of the effluent from the six regulated discharges. The effluent samples will be collected from the discharge stream after the last treatment step on the drilling rig and before the discharge stream enters the ocean. A split of each sample will be collected for chemical and physical analysis as described in the project-specific QAPP. Effluent samples for toxicity analysis will be collected in pre-cleaned plastic jugs (Cubitainer® or equivalent) and kept on ice in coolers under proper chain-of-custody (CoC) procedures, as outlined in the project-specific QAPP associated with this program.

4.1.1.2. Discrete Water Samples (Plume Monitoring)

Plume tracking will be conducted by integrating water column velocity data to predict the plume direction and inform the location of water column profile and discrete sample collection. Water column profiles will be accomplished with a CTD system augmented with a transmissometer sensors for turbidity measurements. The CTD is connected to a rosette water sampler which collects discrete water samples at various depths. Sensor data and discrete water samples will be collected to provide information on water column chemical and physical characteristics within and outside of the plume(s). Discrete water samples will be collected for water-chemistry and water-quality measurements.

Field SOPs and accuracy and precision for the instruments are included in the project-specific QAPP.

4.1.1.3. Water-Based Drilling Fluid and Drill-Cuttings

Two samples of used water-based drilling fluid and two samples of drill-cuttings will be collected during each of the primary time periods of the drilling in Phase II that will include plume-monitoring, with the exception of drill-cuttings during the bulk drilling fluid discharge (if this event occurs) (see Table 7). Sample-collection methods, containers, storage requirements, and holding-time requirements are detailed in the project-specific QAPP. Water-based drilling fluid compositions and monitoring records will be obtained from the drill-rig supervisor as available.

4.1.2. Collection of Phase III and Phase IV Samples

4.1.2.1. Physical Sea-bottom Survey

SPI and/or similar photography techniques will be used to monitor the physical and benthic-infaunal characteristics in surface sediments (upper 10–20 cm) in the study area after exploratory drilling is completed (Phase III). If real time assessment of the images in the field suggests a steep gradient between sites with noticeable deposition and sites with no visual signs of disturbance, the system will be deployed between the predetermined locations based on best professional judgment in the field, in conjunction with logistical constraints and/or weather conditions. Field SOPs are included in the project-specific QAPP.

4.1.2.2. Benthic Ecology Sampling

Benthic invertebrates will be sampled with techniques and methods consistent with those used for the CSESP for community ecology (Blanchard et al. 2011). Infauna will be collected with a double van Veen grab and then sieved through a 1.0-mm-mesh screen (the standard for investigations in Alaska with fine sediments). Five replicate samples will be collected at each sampling location. Field SOPs are included in the project-specific QAPP. Sea water and fine sediments resulting from the grab surveys will be discharged overboard from the monitoring vessel in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL). The details of the washdown procedures are presented in Appendix D.

4.1.2.3. Sediment Sampling

Sediments will be sampled at up to 17 sample-design near-field stations as well as the far-field stations, as described in Section 3.3.3, with a double van Veen grab sampler. Sediment samples will be collected from the top 2 cm of sediments. Depending on sediment observations from van Veen grab collections, gravity-core samples also may be collected in the field to obtain truly undisturbed cross-sectional samples of the sediment layer and to provide information on area and depth/thickness of solids deposition. If collected, the sediment-core samples would be obtained most likely in the immediate vicinity of the drilling location and at the stations located within the 100-m and 250-m concentric radii from the drill site in the direction of the prevailing current during activity. If evidence exists in the field beyond the 100-m radii of drilling fluid and drill-cuttings thicker than expected based on model predictions, additional core samples may be taken. The decision concerning additional coring will be made at the discretion of the field team leads.

During collection of sediment samples, extreme care will be taken to avoid contact with hydrocarbon sources and any possible metals contamination. For example, samples will be collected from the internal portion of the sampler, not from the sides that are touching the actual van Veen grab. Field SOPs are included in the project-specific QAPP.

4.1.2.4. Biological Sampling for Bioaccumulation Monitoring

Both clams (benthic) and amphipods (epibenthic) will be collected for bioaccumulation monitoring. As discussed previously, bivalve (clam) samples will be collected using a combination of a clam rake and a double van Veen grab sampler at the same station. Previous efforts at collecting bivalves and other benthic organisms in the Chukchi Sea during the 2008 CSESP and the 2012 DMP indicated that clams are not obtained with the double van Veen grab sampler in numbers adequate for the tissue volumes required for chemical analyses. However, use of a clam rake towed for a few minutes typically allows for collection of numerous bivalves. Because sample size is important for chemical analysis (i.e., having enough sample volume for all analyses), the use of the clam rake is warranted for bivalve collection. Target bivalve species include *Astarte* spp. and *Macoma* spp. Amphipod samples will also be attempted for collection at the same stations as those for clam sampling, using baited modified minnow-traps. The species of the bivalves and amphipods will be determined as best as possible in the field. However, species will be confirmed by taxonomic identification. Field SOPs are included in the project-specific QAPP.

4.2. Laboratory Methods

A project-specific QAPP is presented in conjunction with this EMP and will be used for the execution of all laboratory-based analyses. The QAPP describes the analytical requirements in detail, including detailed method descriptions or references for sample preparation protocols, instrument calibration, and sample analysis specifications. Measurement-quality objectives (MQOs), such as method detection limits, quality assurance [QA]/ quality control [QC] program and criteria, data reporting and qualifying scheme are also described in the QAPP. Additionally, the laboratory requirements for the benthic community structure analysis and digital photographic analysis are presented in the QAPP.

4.2.1. Samples for Metals Analysis

Samples of drill-cuttings, mud samples, water, sediments, and tissues will be analyzed for the suite of metals required by Permit No.: AKG-28-8100. The analyses will be conducted following protocols that have been developed specifically for reliable trace-level analysis of the target metals in complex marine environmental samples. The analytical protocols have been used extensively for baseline characterization and monitoring the potential impact of offshore oil and gas activities in Alaska, including in the CSESP, COMIDA CAB, Arctic Nearshore Impact

Monitoring In Development Area (ANIMIDA) and Continuing Arctic Nearshore Impact Monitoring In Development Area (cANIMIDA) programs.

4.2.1.1. Water

Water collected for dissolved metal samples during drilling activities (Phase II) will be analyzed for the suite of metals required by Permit No.: AKG-28-8100. Water collected for particulate metal samples during the plume-monitoring component in Phase II will also be analyzed for the same suite of metals. Details can be found in the project-specific QAPP.

4.2.1.2. Sediments

Drilling fluid and drill-cuttings samples collected during Phase II and sediment samples collected during Phases III and IV will be analyzed for the suite of metals required by Permit No.: AKG-28-8100. Details can be found in the project-specific QAPP.

4.2.1.3. Tissue

Tissue samples collected during Phases III and IV will be analyzed for the suite of metals required by Permit No.: AKG-28-8100. Details can be found in the project-specific QAPP.

4.2.2. Samples for Hydrocarbon Analysis

Samples of water, drilling mud, cuttings, sediment and tissues will be analyzed for a suite of VOCs (only in water and drilling fluid and drill-cuttings), PAH, petroleum biomarkers (not analyzed in water), TPH and SHC compounds. The analyses will be conducted following protocols that have been developed specifically for reliable trace-level analysis of the target parameters in complex marine environmental samples. The analytical protocols have been used extensively for baseline characterization and monitoring the potential impact of offshore oil and gas activities in Alaska, including in the CSESP, ANIMIDA, and cANIMIDA programs and are described in the project-specific QAPP.

4.2.2.1. Water

Water samples collected during Phase II will be extracted for VOC (TAH), PAH, SHC and TPH, following laboratory SOPs (see project-specific QAPP). Detailed analytical methods and additional information are described in the QAPP.

4.2.2.2. Sediment

Samples of water-based drilling fluid and drill-cuttings collected during Phase II and sediment samples collected during Phases III and IV will be analyzed for VOCs (drilling fluid and drill-cuttings only), PAH, SHC, TPH and petroleum biomarkers, following laboratory SOPs. Sediment grain size and TOC content of the sediments will also be determined. Detailed analytical methods and additional relevant information are described in the project-specific QAPP.

4.2.2.3. Tissue

Samples of biological tissues collected during Phases III and IV will be analyzed for PAH, SHC and TPH, and petroleum biomarkers following laboratory SOPs. Detailed analytical methods and additional relevant information are described in the project-specific QAPP.

4.2.3. Samples for Benthic Community Structure and Taxonomic Analysis

Taxonomic analysis will be conducted on infaunal invertebrates to determine community composition. Resulting metrics include taxonomic identification, abundance (individuals m^{-2}), and biomass ($g\ m^{-2}$). SPI and/or similar technologies (e.g., ROV) and plan-view photography will be analyzed according to methods described by Blake et al. (2009), with results incorporated into the community analyses. QC methods for benthic taxonomic analysis will follow guidelines outlined in Blanchard et al. (2010) adapted from the EPA Environmental Monitoring and Assessment Program (www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/field/labman.html). Detailed methods and additional relevant information are described in the project-specific QAPP.

4.2.4. Analysis of Photographic Images

For SPI digital photography (plan-view and profile), the range of summarized parameters assessed in the photographic images include: aerial (horizontal and vertical delineation) sediment grain size, prism penetration, surface relief, apparent color redox potential discontinuity layer, surface features, subsurface features, successional stage. In the event that an ROV or camera-sled is used instead of SPI, only plan-view images will be analyzed. This evaluation will include determining the aerial (horizontal) extent of drilling fluids and drill-cuttings. Detailed methods and additional relevant information are described in the project-specific QAPP.

4.2.5. Samples for Toxicity Testing

Test methods for conducting the initial toxicity screening test and the WET testing on specified waste streams are summarized below in Table 9. Additional details can be found in the project-specific QAPP. Upon receipt of the toxicity samples at the laboratory, water quality characteristics will be assessed, depending on the particular requirements as laid out in the SOPs. For example, salinity and dissolved oxygen will be measured. These data can then be used to assess whether physical/chemical conditions are similar between the initial toxicity screening test and (in the event that a positive initial toxicity screening result is obtained) the WET test. No chemical analysis on the initial toxicity screening samples is required by Permit No.: AKG-28-8100.

Table 9: Summary of WET species.

Marine Chronic Toxicity Tests	Species	Method
Larval Fish Seven-Day Larval Survival and Growth Test	Topsmelt (*Atherinops affinis*) or Inland Silverside[1] (*Menidia beryllina*)	EPA/600/R-95/136 EPA-821-R-02-014
Mysid Shrimp Seven-Day Larval Survival, Growth, and Fecundity Test	*Americamysis bahia* (Formerly *Mysidopsis bahia*)	EPA-821-R-02-014
Echinoderm Larval Survival and Development Test	Purple Sea Urchin (*Strongylocentrotus purpuratus*) or Sand Dollar (*Dendraster excentricus*)	EPA/600/R-95/136

[1]Menidia beryllina may be used as a substitute for topsmelt

4.2.6. Quality Control/Quality Assurance (QA/QC)

The quality assurance and quality control component will ensure that the technical components of the project meet existing SOPs to confirm the accuracy, integrity and completeness of the data. Analytical staff members will be responsible for ensuring that sample tracking, sample preparation, and analytical instrument operation all meet QC criteria detailed in the applicable analytical SOPs.

4.2.6.1. Field-Based QA/QC

Standardized field documentation forms will be used to document all sample collection and handling activities, and to track electronically captured data. Field custody of electronic data will be the responsibility of the field survey's chief scientist and/or other responsible party on the monitoring vessel. The field custody of the electronic data consists of creating backups of all electronic data generated each day. The label on the backup media will include a survey ID, date, and name of person creating the backup files. Calibration and maintenance procedures for the sensors that will be used are included in the project-specific QAPP. The QAPP also describes the preparation of field QC samples such as field blanks and field duplicates.

4.2.6.2. Laboratory-Based QA/QC

An integral part of laboratory activities, QC lays out methods for maximizing the quality of operations and analyses, provides analysts with metrics about method performance, and aids project managers in identifying and correcting systematic and random problems. A routine set of QC samples should accompany each set of samples analyzed at the laboratory. Details can be found in the project-specific QAPP.

The MQOs for each QC parameter in this project are presented in the project-specific QAPP. Analytical results that do not meet the MQOs will be submitted to and/or reviewed with the project manager/lead scientist for assessment of the potential impact of the results. Affected samples may be reanalyzed at the project manager's discretion. QC sample data that are accepted outside the MQOs will be indicated with the appropriate data qualifier, and the rationale for accepting the analysis will be documented.

4.2.7. Sample Handling, Storage, Shipping and Custody

All samples collected on the EMP monitoring vessel will be inventoried in a field log book or electronic data acquisition program maintained by the project's chief scientist. All samples will be logged on CoC forms and will be stored in secure areas on the monitoring vessel(s) immediately after collection. Sample names will be cross-checked against the CoC logs prior to packaging samples in coolers for shipment to laboratories.

Sample integrity and custody will be maintained at all times. Every effort will be made to deliver samples to the laboratories in a timely manner with CoC forms inside each cooler. Established procedures will be followed and maintained throughout collection, packaging and shipping. Fully-executed CoCs documenting the sample receipt will be maintained by the laboratories.

5. REPORTING

5.1. First EMP Report

The first EMP report will be submitted no later than June 1 of the year following drilling site operations (Permit section II.A.13.k.2). This EMP report will contain a preliminary analysis of site conditions during active drilling operations and an analysis of post-drilling conditions. Additionally, these data will be compared to existing baseline data.

5.2. Second EMP Report

The second EMP report will be submitted no later than June 1 of the year following completion of Phase IV (Permit section II.A.13.k.3). As per Permit No.: AKG-28-8100, this EMP report will contain:

i. Summary of the results of all stages of environmental monitoring for each EMP Phase;

ii. Discussion of how EMP goals and objectives were accomplished;

iii. Analytical test methods used for data analysis;

iv. Description of any impacts of the effluent on observed sediment pollutant concentration, sediment quality, water quality, benthic community, and marine mammal deflections;

v. Description of the data, evaluations and determinations with regard to each EMP Phase; and

vi. All relevant QA/QC information including, but not limited to, laboratory instrumentation, laboratory procedures, analytical methods detection limits, analytical method precision requirements and sample collection methodology.

5.3. Toxicity Testing Results Reporting

Initial toxicity screening test results will be reported within the discharge monitoring report (DMR) for the month following sample collection. The WET testing results (when WET is required to be performed due to initial toxicity screening failure or a volume that surpasses Permit No.:AKG-28-8100 flow rate requirements and includes chemical additions to the system) will be reported in the DMR that occurs at least two weeks after the completion of the WET testing.

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APPENDIX A

Synthesis of Available Phase I Site Characterization Data for the Burger Prospect

APPENDIX B

OOC Discharge Modeling Reports

APPENDIX C

Thermal Modeling Report

APPENDIX D

Benthic Ecology Sample Washdown Procedures